COMMONWEALTH OF MASSACHUSETTS

massDOT
Massachusetts Department of Transportation
Rail & Transit Division

CONTRACT DOCUMENTS AND SPECIAL PROVISIONS

PROPOSAL NO.	613045-120593
P.V. =	$5,610,000.00
PLANS	YES

FOR

Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line

in the Towns of

LENOX AND LEE

In accordance with the Standard Specifications for Highways and Bridges dated 2022; the Supplemental Specifications dated June 30, 2022, the latest edition of the AREMA Manual for Railway Engineering, MassDOT's MW-1, the Plans, and these Special Provisions

This Proposal to be opened and read: **Thursday, February 9, 2023 @ 2:00 P.M.**

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TABLE OF CONTENTS

END TABLE OF CONTENTS

DOCUMENT 00102

NOTICE TO CONTRACTORS

Electronic proposals for the following project will be received through the internet using COMMBUYS until the date and time stated below. Bid documents will be posted on www.commbuys.com forthwith after the bid submission deadline. No paper copies of bids will be accepted.

All bidders must have or register for a COMMBUYS account in order to bid on this project. If Bidders are not currently registered with COMMBUYS, they need to register with COMMBUYS at least seven-days prior to the scheduled bid opening date

Thursday, February 9, 2023 at 2:00 P.M. **
LENOX AND LEE

Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line
****Date Subject to Change**

PROJECT VALUE = $5,610,000.00

It is highly recommended that bidders attend the Pre-Bid Meeting/Pre-Bid Site Walk which will be held at 10:00 A.M. on Tuesday, January 10, 2023 at the grade crossing at Golden Hill Road in Lee, MA. It is strongly suggested that prospective Bidders have a representative attend this meeting/site walk. The purpose of this meeting/site walk is to discuss any outstanding questions relating to the proposed work, the bidding procedures, or the required contract provisions. Prospective bidders shall bring with them all personal protective equipment which must be worn to access the project site.

It is a requirement that Bidders be pre-qualified under MBTA Class 3 – Trackage, MBTA Class 4A- Steel Superstructures and Class 4B – Concrete Superstructure. The Contractors are required to have the prequalification certificates from MBTA in order to bid on the project. To meet these requirements, it is acceptable that a Contractor is pre-qualified for MBTA Class 4A- Steel Superstructures and Class 4B – Concrete Superstructure and one of his/her subcontractors, who will perform track work, is prequalified for MBTA Class 3 – Trackage. An award will not be made to a Contractor who has not met these requirements prior to the opening of proposals. All prospective Bidders who intend to bid on this project must provide the required MBTA pre-qualification certificates to Scott Conti at the MassDOT Rail and Transit Division by email at Scott.Conti@state.ma.us and June Wu at HDR june.wu@hdrinc.com before 5:00 P. M. on February 8, 2023.

Electronic versions of the contract documents are only available through the COMMBUYS website and these electronic Plans and Specifications will be available on or about December 27,

2022 after 2:00 PM EST. Plans and Contract Documents will be on display and information will be available at the MassDOT Rail and Transit Division Office 10 Park Plaza, Room 4160, Boston, Massachusetts 02116-3973.

Bids will be considered, and the contract awarded in accordance with statutes governing such contracts in accordance with Massachusetts General Laws Chapter 30 § 39M.

All bids shall be accompanied by a Proposal Guaranty in the amount of five percent (5%) of the value of the bid, in accordance with all requirements set forth in Document A00801 Special Provisions.

Electronic proposals will be received through the internet using COMMBUYS until 2:00PM on February 9, 2023 and will be posted on COMMBUYS forthwith after the bid submission deadline. No paper copies of bids will be accepted.

This project is subject to the schedule of prevailing wage rates as determined by the Commissioner of the Massachusetts Department of Labor and Workforce Development and the Division of Occupational Safety.

PRICE ADJUSTMENTS

This Contract contains price adjustments for hot mix asphalt and Portland cement mixtures, diesel fuel, and gasoline. For reference the base prices are as follows: liquid asphalt $665.00 per ton, Portland cement $170.0 per ton, diesel fuel $4.671 per gallon, and gasoline $3.074 per gallon. MassDOT posts the **Price Adjustments** on their Highway Division's website at MassDOT current contract price adjustments | Mass.gov

This Contract contains Price Adjustments for steel. See Document 00813 - PRICE ADJUSTMENT FOR STRUCTURAL STEEL AND REINFORCING STEEL for their application and base prices.

MassDOT Rail and Transit Division projects are subject to the rules and regulations of the Architectural Access Board (521 CMR 1.00 et seq.)

Prospective bidders and interested parties can access this information and more via the internet at WWW.COMMBUYS.COM.

BY: Jamey Tesler, Secretary and CEO, MassDOT
Meredith Slesinger, Administrator, MassDOT Rail and Transit Division
Saturday, December 24, 2022

DOCUMENT 00210

REQUIREMENTS OF MASSACHUSETTS GENERAL LAWS
CHAPTER 30, SECTION 39R;
CHAPTER 30, SECTION 39O

July 1, 1981, updated October 2016

M.G.L. c. 30, § 39R. Award of Contracts; Accounting Statements; Annual Financial Statements; Definitions.

(a) The words defined herein shall have the meaning stated below whenever they appear in this section:

(1) “Contractor" means any person, corporation, partnership, joint venture, sole proprietorship, or other entity awarded a contract pursuant to sections thirty-eight A1/2 to thirty-eight O, inclusive, of chapter seven and any contract awarded or executed pursuant to section eleven C of chapter twenty-five A, section thirty-nine M of chapter thirty, or sections forty-four A to forty-four H, inclusive, of chapter one hundred and forty-nine, which is for an amount or estimated amount greater than one hundred thousand dollars.

(2) "Contract" means any contract awarded or executed pursuant to sections thirty-eight A1/2 to thirty-eight O, inclusive, of chapter seven and any contract awarded or executed pursuant to section eleven C of chapter twenty-five A, section thirty-nine M of chapter thirty, or sections forty-four A through forty-four H, inclusive, of chapter one hundred and forty-nine, which is for amount or estimated amount greater than one hundred thousand dollars.

(3) “Records" means books of original entry, accounts, checks, bank statements and all other banking documents, correspondence, memoranda, invoices, computer printouts, tapes, discs, papers and other documents or transcribed information of any type, whether expressed in ordinary or machine language.

(4) “Independent Certified Public Accountant" means a person duly registered in good standing and entitled to practice as a certified public accountant under the laws of the place of his residence or principal office and who is in fact independent. In determining whether an accountant is independent with respect to a particular person, appropriate consideration should be given to all relationships between the accountant and that person or any affiliate thereof. Determination of an accountant's independence shall not be confined to the relationships existing in connection with the filing of reports with the awarding authority.

(5) “Audit", when used in regard to financial statements, means an examination of records by an independent certified public accountant in accordance with generally accepted accounting principles and auditing standards for the purpose of expressing a certified opinion thereon, or, in the alternative, a qualified opinion or a declination to express an opinion for stated reasons.

(6) "Accountant's Report", when used in regard to financial statements, means a document in which an independent certified public accountant indicates the scope of the audit which he has made and sets forth his opinion regarding the financial statements taken as a whole with a listing of noted exceptions and qualifications, or an assertion to the effect that an overall opinion cannot be expressed. When an overall opinion cannot be expressed the reason therefor shall be stated. An accountant's report shall include as a part thereof a signed statement by the responsible corporate officer attesting that management has fully disclosed all material facts to the independent certified public accountant, and that the audited financial statement is a true and complete statement of the financial condition of the contractor.

(7) “Management", when used herein, means the chief executive officers, partners, principals or other person or persons primarily responsible for the financial and operational policies and practices of the contractor.

(8) Accounting terms, unless otherwise defined herein, shall have a meaning in accordance with generally accepted accounting principles and auditing standards.

(b) Subsection (a)(2) hereof notwithstanding, every agreement or contract awarded or executed pursuant to sections thirty-eight A 1/2 to thirty-eight O, inclusive, of chapter seven, or eleven C of chapter twenty-five A, and pursuant to section thirty-nine M of chapter thirty or to section forty-four A through H, inclusive, of chapter one hundred and forty-nine, shall provide that:

(1) The contractor shall make, and keep for at least six years after final payment, books, records, and accounts which in reasonable detail accurately and fairly reflect the transactions and dispositions of the contractor, and

(2) Until the expiration of six years after final payment, the office of inspector general, and the commissioner of capital asset management and maintenance shall have the right to examine any books, documents, papers or records of the contractor or of his subcontractors that directly pertain to, and involve transactions relating to, the contractor or his subcontractors, and

(3) If the agreement is a contract as defined herein, the contractor shall describe any change in the method of maintaining records or recording transactions which materially affect any statements filed with the awarding authority, including in his description the date of the change and reasons therefor, and shall accompany said description with a letter from the contractor's independent certified public accountant approving or otherwise commenting on the changes, and

(4) If the agreement is a contract as defined herein, the contractor has filed a statement of management on internal accounting controls as set forth in paragraph (c) below prior to the execution of the contract, and

(5) If the agreement is a contract as defined herein, the contractor has filed prior to the execution of the contracts and will continue to file annually, an audited financial statement for the most recent completed fiscal year as set forth in paragraph (d) below.

(c) Every contractor awarded a contract shall file with the awarding authority a statement of management as to whether the system of internal accounting controls of the contractor and its subsidiaries reasonably assures that:

(1) transactions are executed in accordance with management's general and specific authorization;

(2) transactions are recorded as necessary

i. to permit preparation of financial statements in conformity with generally accepted accounting principles, and

ii. to maintain accountability for assets;

(3) access to assets is permitted only in accordance with management's general or specific authorization; and

(4) the recorded accountability for assets is compared with the existing assets at reasonable intervals and appropriate action was taken with respect to any difference.

Every contractor awarded a contract shall also file with the awarding authority a statement prepared and signed by an independent certified public accountant, stating that he has examined the statement of management on internal accounting controls, and expressing an opinion as to:

(1) whether the representations of management in response to this paragraph and paragraph (b) above are consistent with the result of management's evaluation of the system of internal accounting controls; and

(2) whether such representations of management are, in addition, reasonable with respect to transactions and assets in amounts which would be material when measured in relation to the applicant's financial statements.

(d) Every contractor awarded a contract by the commonwealth or by any political subdivision thereof shall annually file with the commissioner of capital asset management and maintenance during the term of the contract a financial statement prepared by an independent certified public accountant on the basis of an audit by such accountant. The final statement filed shall include the date of final payment. All statements shall be accompanied by an accountant's report. Such statements shall be made available to the awarding authority upon request.

(e) The office of inspector general, the commissioner of capital asset management and maintenance and any other awarding authority shall enforce the provisions of this section. The commissioner of capital asset management and maintenance may after providing an opportunity for the inspector general and other interested parties to comment, promulgate pursuant to the provisions of chapter thirty A such rules, regulations and guidelines as are necessary to effectuate the purposes of this section. Such rules, regulations and guidelines may be applicable to all awarding authorities. A contractor's failure to satisfy any of the requirements of this section may be grounds for debarment pursuant to section forty-four C of chapter one hundred and forty-nine.

(f) Records and statements required to be made, kept or filed under the provisions of this section shall not be public records as defined in section seven of chapter four and shall not be open to public inspection; provided, however, that such records and statements shall be made available pursuant to the provisions of clause (2) of paragraph (b).

M.G.L. c. 30, § 39O: Suspension, Delay, or Interruption or Failure to Act by Awarding Authority; Adjustment in Contract Price; Submission of Claims.

Section 39O. Every contract subject to the provisions of section thirty-nine M of this chapter or subject to section forty-four A of chapter one hundred forty-nine shall contain the following provisions (a) and (b) in their entirety and, in the event a suspension, delay, interruption or failure to act of the awarding authority increases the cost of performance to any subcontractor, that subcontractor shall have the same rights against the general contractor for payment for an increase in the cost of his performance as provisions (a) and (b) give the general contractor against the awarding authority, but nothing in provisions (a) and (b) shall in any way change, modify or alter any other rights which the general contractor or the subcontractor may have against each other.

(a) The awarding authority may order the general contractor in writing to suspend, delay, or interrupt all or any part of the work for such period of time as it may determine to be appropriate for the convenience of the awarding authority; provided however, that if there is a suspension, delay or interruption for fifteen days or more or due to a failure of the awarding authority to act within the time specified in this contract, the awarding authority shall make an adjustment in the contract price for any increase in the cost of performance of this contract but shall not include any profit to the general contractor on such increase; and provided further, that the awarding authority shall not make any adjustment in the contract price under this provision for any suspension, delay, interruption or failure to act to the extent that such is due to any cause for which this contract provides for an equitable adjustment of the contract price under any other contract provisions.

(b) The general contractor must submit the amount of a claim under provision (a) to the awarding authority in writing as soon as practicable after the end of the suspension, delay, interruption or failure to act and, in any event, not later than the date of final payment under this contract and, except for costs due to a suspension order, the awarding authority shall not approve any costs in the claim incurred more than twenty days before the general contractor notified the awarding authority in writing of the act or failure to act involved in the claim.

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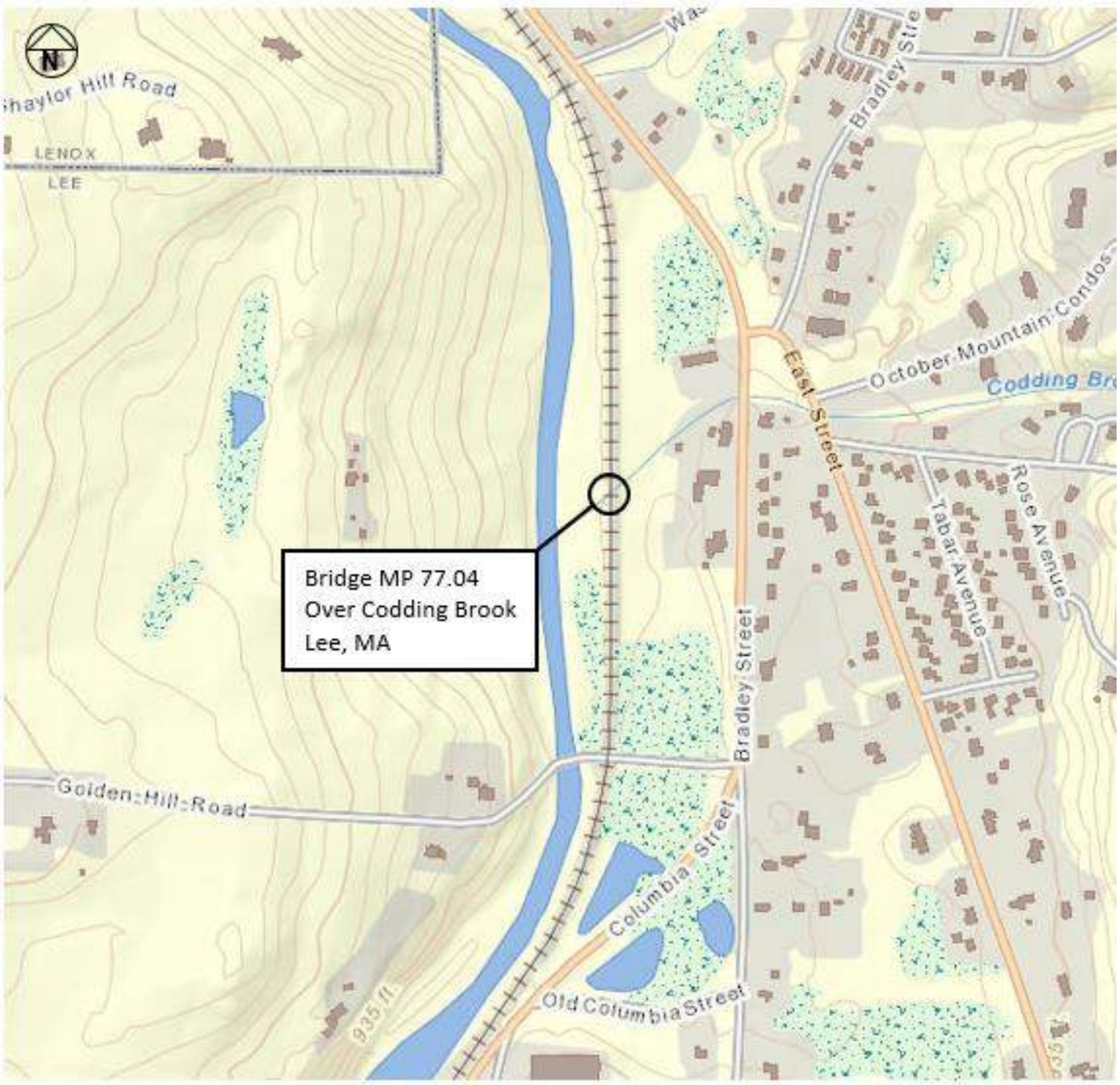
Document 00331

LOCUS MAP

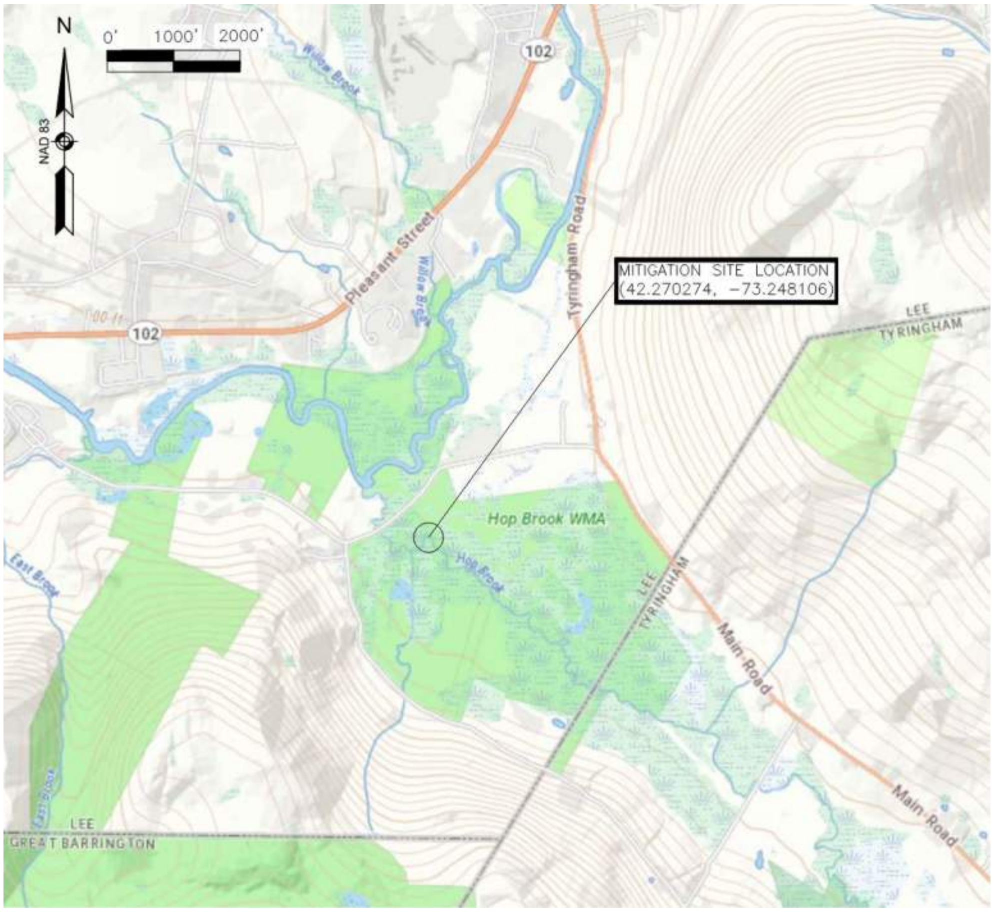
LENOX AND LEE
Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line



LOCATION MAP- BR.77.04
NOT TO SCALE

LOCATION MAP – BR. 79.81

NOT TO SCALE



LOCATION MAP – WETLAND MITIGATION

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DOCUMENT 00439

Final Report ☐

Interim Report ☐

CONTRACTOR PROJECT EVALUATION FORM

For instructions on using this form, see Engineering Directive E-10-002, Dated 4/20/2010

Date: ____________________________________

City/Town: ____ Contractor:_______________________________

Project: ____ Address:_________________________________

F.A. No. ____ Contract Number: _________________________

Bid Price: ____ Notice to Proceed: _________________________

Funds: State:______________ Fed Aid:______________ Current Contract Completion Date:___________

Date Work Started:__________________________________ Date Work Completed*: ____________________

Contractor's Superintendent: ____

Division: (indicates class of work) Highway:_________________Bridge:_________Maintenance: ____________

*If work was NOT completed within specified time (including extensions) give reasons on following page.

	Excellent 10	Very Good 9	Average 8	7	Fair 6	5	Poor 4	% Rating
1. Workmanship								x 2=
2. Safety								x 2=
3. Schedule								x 1.5=
4. Home Office Support								x 1=
5. Subcontractors Performance								x 1=
6. Field Supervision/ Superintendent								x 1=
7. Contract Compliance								x 0.5=
8. Equipment								x 0.5=
9. Payment of Accounts								x 0.5=
(use back for additional comments)						**Overall Rating:**		

(Give explanation of items 1 through 9 on the following page in numerical order if overall rating is below 80%. Use additional sheets if necessary.)

_______________________________________ _______________________________________

District Construction Engineer's Signature/Date Resident Engineer's Signature/Date

____

Contractor's Signature Acknowledging Report/Date

Contractor Requests Meeting with the District: No ☐ Yes ☐ Date Meeting Held:_____________

Contractor's Comments/Meeting Notes (extra sheets may be added to this form and noted here if needed): _________

____

____

CONTRACTOR PROJECT EVALUATION FORM (Continued)

Date: ___________________________________ Contract Number:________________________________

INFORMATION FOR DISTRICT HIGHWAY DIRECTORS RELATING TO PREQUALIFICATION

A deduction shall be recommended for unsatisfactory performance if computed overall rating is under 80%.
A deduction may be recommended for this project being completed late due to the Contractor's fault.

RECOMMENDATIONS FOR DEDUCTIONS FROM CONTRACTORS' ASSIGNED FACTOR
(*Write Yes or No in space provided*)

I recommend a deduction for Contractor's unsatisfactory performance: ____________________________________

I recommend a deduction for project completed late:____

Signed: _____________________________
District Highway Director

EXPLANATION OF RATINGS 1 – 9:____

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WORK NOT COMPLETED WITHIN SPECIFIED TIME: ____

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Revised: 04/28/17

*** END OF DOCUMENT ***

DOCUMENT 00440

Final Report ☐

Interim Report ☐

SUBCONTRACTOR PROJECT EVALUATION FORM

For instructions on using this form, see Engineering Directive E-10-002, Dated 4/20/2010

Date: ______________________________

City/Town: ______________________________ Subcontractor: ______________________________

Project: ______________________________ Address: ______________________________

F.A. No.: ______________________________ Contract Number: ______________________________

Prime Contractor ______________________________ Current Contract Completion Date: ____________

Date Work Started: ______________________________ Date Work Completed*: ______________________________

Subcontractor's Superintendent: ______________________________

Type of Work Performed by Subcontractor: ______________________________

*If work was NOT completed within specified time (including extensions) give reasons on following page.

	Excellent 10	Very Good 9	Average 8	7	Fair 6	5	Poor 4	% Rating
1. Workmanship								x 2=
2. Safety								x 2=
3. Schedule								x 1.5=
4. Home Office Support								x 1.5=
5. Field Supervision/ Superintendent								x 1=
6. Contract Compliance								x 1=
7. Equipment								x 0.5=
8. Payment of Accounts								x 0.5=
(use back for additional comments)						**Overall Rating:**		

(Give explanation of items 1 through 8 on the following page in numerical order if overall rating is below 80%. Use additional sheets if necessary.)

______________________________ District Construction Engineer's Signature/Date

______________________________ Resident Engineer's Signature/Date

______________________________ Contractor Signature Acknowledging Report/Date

______________________________ Subcontractor Signature Acknowledging Report/Date

Subcontractor Requests Meeting with the District: No ☐ Yes ☐ Date Meeting Held:____________

Subcontractor's Comments / Meeting Notes (extra sheets may be added to this form and noted here if needed): ____

____

____

Contractor's Comments: ______________________________

____

SUBCONTRACTOR PROJECT EVALUATION FORM (Continued)

Date: ___________________________________ Contract Number:_________________________________

INFORMATION FOR DISTRICT HIGHWAY DIRECTORS RELATING TO PREQUALIFICATION

A deduction shall be recommended for unsatisfactory performance if computed overall rating is under 80%.
A deduction may be recommended for this project being completed late due to the Contractor's fault.

RECOMMENDATIONS FOR DEDUCTIONS FROM CONTRACTORS' ASSIGNED FACTOR
(*Write Yes or No in space provided*)

I recommend a deduction for Contractor's unsatisfactory performance: ______________________________

I recommend a deduction for project completed late:____

Signed: ______________________________
District Highway Director

EXPLANATION OF RATINGS 1 – 8: ____

WORK NOT COMPLETED WITHIN SPECIFIED TIME: _______________________________________

Revised: 04/28/17

*** END OF DOCUMENT ***

DOCUMENT 00710
GENERAL CONTRACT PROVISIONS
Revised: 04/08/22

NOTICE OF AVAILABILITY

The STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES dated 2022, the SUPPLEMENTAL SPECFICATIONS, the 1996 METRIC CONSTRUCTION AND TRAFFIC STANDARD DETAILS, the 1990 STANDARD DRAWINGS FOR SIGNS AND SUPPORTS; the 1968 STANDARD DRAWINGS FOR TRAFFIC SIGNALS AND HIGHWAY LIGHTING and the 2017 CONSTRUCTION STANDARD DETAILS are available online at https://www.mass.gov/massdot-highway-division-manuals-and-publications

The foregoing documents are incorporated by reference herein. References to "Engineer" in the foregoing documents shall mean "Project Manager", "PM", or "Scott Conti."

SPECIAL PROVISIONS FOR RIGHT-TO-KNOW ACT REOUIREMENTS

The Contractor's attention is directed to Massachusetts General Laws, Chapter 111 F, commonly known as the Right- To-Know Act, and to the regulations promulgated pursuant thereto. Among the provisions of the Right-To-Know Act is a requirement that employers make available to employees Materials Safety Data Sheets (MSDS) for any substance on the Massachusetts Substance List (MSL) to which employees are, have been, or may be exposed.

To ensure prompt compliance with these regulations and legislation, the Contractor shall:

1. Deliver to the Department, prior to the start of any work under this contract, copies of MSDS for all MSL substances to be used, stored, processed or manufactured at the worksite by the Contractor.

2. Train employees of the Department, who may be exposed to MSL substances as a result of the Contractor's work under this contract, with regard to those specific substances in accordance with requirements of the Right-To-Know Act.

3. Observe all safety precautions recommended on the MSDS for any MSL substance to be used, stored, processed, or manufactured at the worksite by the Contractor.

4. Inform the Department in writing regarding specific protective equipment recommended in the MSDS for MSL substances to which employees of the Department may be exposed as a result of the Contractor's work under this contract.

The Department shall not be liable for any delay or suspension of work caused by the refusal of its employees to perform any work due to the Contractor's failure to comply with the Right-To-Know Act. The Contractor agrees to hold the Department or the Commissioner of the Department harmless and fully indemnified for any and all claims, demands, fines, actions, complaints, and causes of action resulting from or arising out of the Contractor's failure to comply with the requirements of the Right-To-Know Act.

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DOCUMENT 00718

SPECIAL PROVISION FOR PARTICIPATION BY MINORITY OR WOMEN'S BUSINESS ENTERPRISES AND SERVICE- DISABLED VETERAN- OWNED BUSINESS ENTERPRISES
(Implementing Chapter 102, Section 24 and
Chapter 273, Section 124, of the Acts of 1994 and Chapter 56, Sections 1 to 5 of the Acts of 2010 and subsequent Acts)
Revised September 27, 2021

I. PARTICIPATION

M/WBE PARTICIPATION GOAL
On this Contract, the Massachusetts Department of Transportation (MassDOT) has established a goal for participation by Minority or Women Business Enterprise(s) (M/WBE). One half of the goal shall be met in the form of contractor activity. This goal shall remain in effect throughout the life of the Contract.

☒ Design-Bid-Build Projects: M/WBE Participation Goal __5.4%
(*One half of this goal shall be met in the form of Subcontractor construction activity*)

☐ Design-Build Projects: M/WBE Design Participation Goal ___% and M/WBE Construction Participation Goal ___%
(One half of the Construction Goal shall be met in the form of Subcontractor construction activity)

SDVOBE PARTICIPATION BENCHMARK
On this Contract, the Massachusetts Department of Transportation (MassDOT) has established a goal for participation by Service- Disabled Veteran- Owned Business Enterprise(s) (SDVOBE). This goal shall remain in effect throughout the life of the Contract.

☐ Design-Bid-Build Projects: SDVOBE Participation Goal ____%

☐ Design-Build Projects: SDVOBE Design Participation Goal ___% and SDVOBE Construction Participation Goal ___%

II. POLICY

It is the policy of the MassDOT that Minority, Women Business Enterprises (M WBEs) and Service- Disabled Veteran- Owned Business Enterprises (SDVOBEs) have equal opportunity to receive and participate in the performance of its state funded Contracts.

III. M/WBE and SDVOBE OBLIGATION

The Contractor agrees to take all necessary and reasonable steps to ensure that MBE, WBE, and SDVOBEs have the maximum opportunity to compete for, and to perform, Department Contracts.

IV. FAILURE TO COMPLY WITH M/WBE OR SDVOBE REQUIREMENTS

All Contractors and Subcontractors are hereby advised that failure to carry out the requirements of these Provisions constitutes a breach of Contract which may result in termination of the Contract, a determination that the Contractor or Subcontractor be barred from bidding on Department Contracts for up to three (3) years, or any other remedy as the Department may impose under Section XIV of these Special Provisions.

V. REQUIRED SUBCONTRACT PROVISIONS

The Prime Contractor shall include the Provisions of Sections II, III, and IV above in every subcontract making those provisions binding on each subcontractor, supplier, manufacturer, consultant or service provider.

VI. DEFINITIONS

For the purpose of these Special Provisions, the terms listed below are defined as follows:

Minority Business Enterprise or MBE means any individual, business organization, or non-profit corporation certified as a MBE by the Supplier Diversity Office (SDO), formerly known as the State Office of Minority and Women Business Assistance (SOM WBA), or by the Department for the purposes of a particular bid or proposal to be submitted to the Department.

Women Business Enterprise or WBE means any individual, business or organization, or non-profit corporation certified as a WBE by SDO, or by the Department for the purposes of a particular bid or proposal to be submitted to the Department.

Service- Disabled Veterans- Owned Businesses or SDVOBE means a business not less than 5 I percent of which is owned by one or more service- disabled veterans or, in the case of any publicly owned business, not less than 5 I percent of the stock of which is owned by one or more service-disabled veterans; and the management and daily business operations of which are controlled by one or more service- disabled veterans or, in the case of a veteran with permanent and severe disability, the spouse or permanent caregiver of such veteran.

"Contractor activity" means any work, including but not limited to, construction, demolition, renovation, survey, test boring services, or maintenance work performed under the Contract.

“Approved Joint Venture" means a joint venture between M/WBEs and non-M/WBEs, or SDVOBEs and non- SDVOBEs, which has been established for the purpose of participation on a particular contract, where:

1. The M/WBE or SDVOBE partner(s) shares in the ownership, control, management responsibilities, risks and profits of the joint venture; and

2. The Joint Venture has been approved by the Department for M/WBE or SDVOBE participation on the particular contract.

"Equipment Rental Firm" means a firm that owns equipment and assumes actual and contractual responsibility to rent said equipment to perform a useful function of the work of the contract consistent with normal industry practice.

“Material Supplier" means a vendor engaged in sales to the highway construction industry from an established place of business or source of supply, which:

(a) Manufactures goods from raw materials or substantially alters them before resale, or

(b) Provides and maintains a storage facility for materials used in the work, consistent with normal industry practice.

“Department” means the Massachusetts Department of Transportation (MassDOT).

"SDO” means the Massachusetts Supplier Diversity Office.

VII ELIGIBILITY of M/WBEs

Only firms, *OTHER THAN THE PRICE CONTRACTOR*, which have been certified by SDO and/or the Department as eligible to participate on state funded contracts as MBEs or WBEs may be used on this contract for credit toward the toward the M/WBE participation goal

1. SDO Directory of Certified M/WBEs: The Supplier Diversity Office publishes a Directory of certified MBE and WBEs. This Directory can be obtained from SDO at https: www somwba.state.ma.us. This site lists those *firms* which have been certified as minority owned (MBEs) or women owned (WBEs) in accordance with the criteria of 425 CMR 2 00 et seq to participate as M/WBEs on state funded contracts. It also lists the kinds of work in which each firm engages but does not constitute an endorsement of the quality or performance of any business and does not represent Department subcontractor approval.

2. Application for Certification by the Department for a Particular Project: A firm which has (1) submitted a fully completed M/WBE application to SDO at least 30 days previously, (2) has provided in a timely manner, any additional information which may have been requested by SDO, and t3) can provide evidence, satisfactory to the Department, of a bidder's conditional commitment to subcontract with the firm, if certified, may apply directly to the MassDOT Office of Civil Rights to be certified for participation on the particular contract.

3. Joint Venture Approval. To obtain recognition as an approved joint venture between M/WBEs and non-.'M/WBEs, the Joint Venture must provide to the MassDOT Office of Civil Rights, at least l4 business days before the bid opening date, the Joint Venture Affidavit Document B00847, and a copy of the Joint Venture Agreement, which shall include a detailed breakdown of the following:

   (a) Capital participation by the M/WBE,

   (b) Specific equipment to be provided to the Joint Venture by the M/WBE,

   (c) Specific responsibilities of the M/WBE in the management of the Joint Venture,

   (d) Workforce and specific skills to be provided to the Joint Venture by the M/WBE, and

   (c) Percentage distribution to the M WBE of the projected profit or loss incurred by the Joint Venture.

   (f) The Joint Venture shall provide all such additional information as may be requested by the Department for the purpose of determining joint venture eligibility.

VIII. ELIGIBILITY of SDVOBEs

Only firms, *OTHER THAN THE PRICE CONTRACTOR*, which have demonstrated that they are listed as a service- disabled veteran- owned small businesses within the VetBiz database may be used on this contract for credit toward the SDVOBE participation goal

1. VetBiz Database' The website, located at cv.VetBiz.gov, listing verified service- disabled veteran- owned businesses.

2. Joint Venture Approval: To obtain recognition as an approved joint venture between SDVOBEs and non-'SDVOBEs, the joint venture must provide to the MassDOT Office of Civil Rights, at least 14 business days before the bid opening date, an application for joint venture participation approval, and a copy of the Joint Venture Agreement, which shall include a detailed breakdown of the following:

   (a) Capital participation by the SDVOBE,

   (b) Specific equipment to be provided to the joint venture by the SDVOBE,

   (c) Specific responsibilities of the SDVOBE in the management of the Joint Venture,

   (d) Workforce and specific skills to be provided to the joint venture by the SDVOBE, and

(e) Percentage distribution to the SDVOBE of the projected profit or loss incurred by the Joint Venture.

(f) The Joint Venture shall provide all such additional information as may be requested by the Department for the purpose of determining joint venture eligibility.

IX. COUNTING M. WBE PARTICIPATION AND SDVOBE BENCHMARKS TOWARDS M/WBE AND SDVOBE GOALS

In order for M/WBE participation and SDVOBE benchmarks to count toward the Contract goal, the M/WBE and SDVOBE must have independently managed, supervised and performed the Contract work with its own workforce, equipment and resources. M/WBE and SDVOBE participation which fulfills these requirements shall be counted toward meeting the M/WBE and SDVOBE goals in accordance with the following rules:

I If a firm has been determined to be an eligible MBE, WBE or SDVOBE, the total dollar value of the contract performed by the M/WBE or SDVOBE is counted toward the applicable goal as follows:

a. Except as provided below, in Section IX (1)(g). work performed by a M/WBE or a SDVOBE Prime Contractor shall not be counted toward the M/WBE or SDVOBE goal, and all Prime Contractors, including M/WBE or SDVOBE Prime Contractors, must comply with the M/WBE and SDVOBE requirements of this Contract

b. For a M/WBE or SDVOBE material supplier, sixty percent (60%) of the amount to be paid for materials and supplies required under this Contract shall be credited toward the goal.

c. For a M/WBE or SDVOBE who provides a bonafide service such as professional, technical, consultant or managerial services and assistance in the procurement of essential personnel, facilities, equipment, materials, or supplies required for performance of the contract, reasonable fees or commissions charged for the service shall be listed, but the cost of items themselves shall not be credited.

d. For a M WBE or SDVOBE hauler, trucker, or delivery service, which is not also the manufacturer of or a regular dealer in the materials and supplies, reasonable fees charged for delivery of materials and supplies required on the job site shall be credited the cost of the materials and supplies themselves shall not be credited.

e. For a M/WBE or SDVOBE who provides any bonds or insurance specifically required for the performance of the contract, reasonable fees or commissions charged for such service shall be listed, but the face amount or actual premium paid for the bond or insurance shall not be credited

f. The Department shall determine if the fees or commissions listed in accordance with paragraphs (c), (d), and (e) are not excessive as compared with fees or commissions customarily allowed for similar services

g. That portion of the contract total dollar value equal to the percentage of ownership and control of the M/WBE partner(s) or SDVOBE partner(s) in an approved Joint Venture shall be counted toward the Contract goal, except that credit for M/WBE and SDVOBE participation in an approved Prime Joint Venture shall not exceed one half of the Contract goal.

X. JOINT CHECK POLICY

1. MassDOT recognizes that the use of joint checks may be a business practice required by material suppliers and vendors in the construction industry. A joint check is a two-party check issued by a/the Prime Contractor lo a M/WBE or SDVOBE third party such as a regular dealer of material or supplies. The Prime Contractor issues the check as payor to the M/WBE or SDVOBE and the third party jointly as payees to guarantee payment to the third party for materials or supplies obtained or to be used by the M,'WBE or SDVOBE. MassDOT has established criteria to ensure that M/WBEs or SDVOBEs are in fact performing a commercially useful function (“CUF”) while using a joint check arrangement. Contractors and M/WBEs or SDVOBEs must meet and conform to these conditions and criteria governing the use of joint checks.

2. In the event that a Contractor, M/WBE or SDVOBE Subcontractor desires to a use joint check, MassDOT will require prior notice and will closely monitor the arrangement for compliance. MassDOT may allow a joint check arrangement and give credit to a Contractor for use of the M/WBE or SDVOBE where one or more of the following conditions exist:

- The use of a joint check is in fact required by this type of vendor or supplier as a standard industry practice that applies to all Contractors (M/WBEs, SDVOBE and non-M/WBEs or non-SDVOBEs); or is required by a specific vendor or supplier;

- Payment for supplies or materials would be delayed for an unreasonably extended period without the joint check arrangement;

- The M/WBE or SDVOBE (or any of its Subcontractors) has a pattern or history of not paying a vendor or supplier within a reasonable time or has not established enough of a credit history with the supplier or vendor, and/or

- The presence of severe adverse economic conditions, where credit resources may be limited and such practices may be necessary or required to effect timely payments.

3. Other factors MassDOT may consider:
   - Whether there is a requirement by the Prime Contractor that a M/WBE or SDVOBE should use a specific vendor or supplier to meet their Subcontractor specifications;

   - Whether there is a requirement that a M/WBE or SDVOBE use the Prime Contractor's negotiated price;

   - The independence of the M/WBE or SDVOBE;

   - Whether approval has been sought prior to use of a joint check arrangement; and

   - Whether any approved joint check arrangement has exceeded a reasonable period of use;

   - The operation of the joint check arrangement; and

   - Whether the M/WBE or SDVOBE has made an effort to establish alternate arrangements for following periods (i.e., the M/WBE or SDVOBE must show it can, or has, or why it has not, established or increased a credit line with the vendor or supplier).

Even with the use of a Joint Check, both the Contractor and M/WBE or SDVOBE remain responsible for compliance with all other elements of the Special Provisions, and must still be able to prove that a commercially useful function is being performed for the Contractor.

XI. JOINT CHECK PROCEDURES

- The M/WBE or SDVOBE advises its General or Prime Contractor that it will have to use a Joint Check and provide proof of such requirement.

- The General or the Prime Contractor submits a request for approval to MassDOT, using MassDOT's approved Joint Check Request form (Document B00846) and by notification on the M/WBE Letter of Intent (Document B00843) or SDVOBE Letter of Intent (Document B00845), and any other relevant documents. Requests that are not initiated during the bid process should be made in writing and comply with the procedure.

- The Contractor and M/WBE or SDVOBE must have:

  (a) a written agreement with the material supplier vendor;
  (b) applied for credit with the subject material supplier and has supplied the vendor's response;

(c) shown that it will place all orders to the subject material supplier/vendor;

(d) made and retains all decision-making responsibilities concerning the materials; and

(e) provided a Joint Check Agreement that is acceptable to MassDOT;

- The MassDOT Office of Civil Rights will review the request and render a decision as part of the approval process for M/WBE or SDVOBE Schedules and Letters of Intent.

- Review and Approval will be project specific and relevant documents will be made part of the Project Contract file.

- Payments should be made in the name of both the M/WBE or SDVOBE and vendor or supplier. Payments should be issued and signed by the Contractor as only the guarantor for prompt payment of purchases to the vendor or supplier. The payment to the vendor or supplier should be handled by the M/WBE or SDVOBE (i.e. if possible, funds or the joint check should be processed by the M/WBE or SDVOBE and sent by the M/WBE or SDVOBE to the vendor or supplier).

- MassDOT may request copies of cancelled checks (front and back) and transmittal information to verify any payments made to the M/WBE or SDVOBE and vendor or supplier.

- MassDOT may request other information and documents, and may ask questions of the Contractor, Subcontractor and vendor or supplier prior to, during, and after the project performance to ascertain whether the Subcontractor is performing a commercially useful function and all parties are complying with M/WBE or SDVOBE Program policies and procedures as part of the Subcontractor approval process.

XII. AWARD DOCUMENTATION AND PROCEDURES

1. The two lowest bidders ’the two bidders with the lowest price per quality score point, including any M/WBE bidder or SDVOBE bidder, shall submit, by the close of business on the third business day after the bid opening, a completed Schedule of M/WBE and SDVOBE participation, in the form attached, which shall list:

   a. The full company name, address and telephone number of each M/WBE or SDVOBE with whom the bidder intends to make a commitment;

   b. The Contract item(s), by number(s) and quantity(res), if applicable, or specific description of other business activity to be performed by Each M/WBE or SDVOBE as set forth in the Letters of Intent. The bidder shall list only firms which have the capacity to perform, manage and supervise the work proposed in accordance with the requirements of Section XII of these Special Provisions.

   c. The total dollar amount to be paid lo each M WBE or SDVOBE. (8idders are cautioned that at least one half of the participation goal must be met with Contract work.)

   d. The total dollar amount to be paid to each M/WBE or SDVOBE which is eligible for credit toward the M/WBE or SDVOBE goal under the crediting rules set out in Section IX.

   e. The total creditable M/WBE or SDVOBE participation as a percentage of the total bid price.

2. All firms listed on the Schedule must be currently certified.

3. The two lowest bidders/the two bidders with the lowest price per quality score point shall submit with their Schedules of Participation, fully completed, signed Letters of Intent from each of the M/WBEs or SDVOBEs listed on the Schedule. The Letters of Intent shall be in the form attached and shall identify specifically the contract activity the M/WBE or SDVOBE proposes to perform, expressed **as contract item** number, if applicable, description of the activity, quantity, unit price and total price. In the event of discrepancy between the Schedule and the Letter of Intent, the Letter of Intent shall govern.

4. Evidence of good faith efforts will be evaluated by the Department in the selection of the lowest responsible bidder/best value bidder. All information requested by the Department for the purpose of evaluating the bidder's efforts to achieve the goal must be provided within three calendar days and must be accurate and complete in every detail. The apparent low bidder's/best value bidder's attainment of the **M/WBE** or SDVOBE goal or a satisfactory demonstration of good faith efforts is a prerequisite for Award of the Contract.

5. Failure to meet, or to demonstrate good faith efforts to meet, the requirements of these Special Provisions shall render a bid non-responsive. Therefore, in order to be eligible for award, the bidder (1) must list on the Schedule of Participation, and provide the required Letters of Intent for, M/WBE or SDVOBE participation which meets or exceeds the **Contract goal in** accordance with the terms of these Special Provisions or (2) must demonstrate, to the satisfaction of the Department, that good faith efforts were made to achieve the goal.

6. If the Department finds that the percentage of M/WBE or SDVOBE participation submitted by the bidder on its Schedule does not meet the Contract goal, or that the Letters of Intent were not timely filed, and that the bidder has not demonstrated good faith efforts to comply with these requirements, it shall propose that the bidder be declared ineligible for Award. In that case, the bidder may request administrative reconsideration. Such requests must be sent in writing within three calendar days of receiving notice of proposed ineligibility to: The Office of the General Counsel, Massachusetts Department of Transportation. 10 Park Plaza, Boston, MA. 02116.

7. If, after administrative reconsideration, the Department finds that the bidder has not shown that sufficient good faith efforts were made to comply with the requirements of these Special Provisions it shall reject the bidder's proposal and may retain the proposal guaranty.

8. Actions which constitute evidence of good faith efforts to meet the M/WBE or SDVOBE goals include, but are not limited to, all of the following examples:

   a. Efforts made to select portions of the work proposed to be performed by M/WBEs or SDVOBEs in order to increase the likelihood of achieving the stated goal, including, where appropriate, but not limited to, breaking down contracts into economically feasible units to facilitate M/WBE and **SDVOBE** participation. The value of such work is required to at least equal the M/WBE and SDVOBE goal.

   b. Reasonable written notification prior to the opening of bids soliciting individual M/WBEs or SDVOBEs interested in participation in the contract as subcontractors, regular dealers, manufacturers, consultants, or service providers and identifying the specific items or type of work being solicited.

   c. Written notification to M WBE or SDVOBE economic development assistance agencies and organizations which provide assistance in recruitment and placement of M/WBEs and SDVOBEs, describing the type of work, supplies or services being considered for M/WBE or SDVOBE subcontracting on this contract.

   d. Efforts made to negotiate with M 'WBEs or SDVOBEs for specific items of work including evidence of:

      (1) The names, addresses, telephone numbers of M WBEs or SDVOBEs who were contacted, the dates of initial contact and whether initial solicitations of interest were followed up by contacts with M/WBEs or SDVOBEs to determine with certainty whether the M/WBEs or SDVOBEs were interested. Personal or phone contacts are expected.

      (2) A description of the information provided by the M/WBEs or SDVOBEs regarding the plans and specifications and estimated quantities for portions of the work to be performed.

      (3) A statement of why additional agreements with M/WBEs or SDVOBEs were not reached.

      (4) Documentation of each M/WBE or SDVOBE contacted but rejected and the reasons for the rejection.

   e. Absence of any agreements between the Contractor and the M/WBE or SDVOBE in which M/WBE or SDVOBE promises not to provide subcontracting quotations to other bidders.

   f. Efforts made to assist the M 'WBEs or SDVOBEs that need assistance in obtaining bonding, insurance, or lines of credit required by the Contractor.

f. Documentation that qualified M/WBEs or SDVOBEs are not available, or are not interested.

g. Attendance at any meeting scheduled by the Department to encourage better Contractor-M/WBE or Contractor- SDVOBE relationships and/or to inform M/WBEs or SDVOBEs of forthcoming M/WBE or SDVOBE utilization opportunities

h. Advertisement, in general circulation media, in trade association publications and in disadvantaged business enterprise-focused media, of Interest in utilizing M/WBEs or SDVOBEs and the area of interest.

i. Efforts to effectively use the services of available minority community organizations; women organizations, veteran organizations, minority, women disadvantaged and veteran contractor's groups; local, state and federal disadvantaged business assistance offices; and other organizations that provide assistance in recruitment and placement of M/WBEs or SDVOBEs.

9. The demonstration of good faith efforts must establish that the Contractor has actively and aggressively sought out M/WBEs or SDVOBEs to participate in the project and has taken all actions which could be reasonably expected to achieve the goal. Examples of circumstances or actions not acceptable as reasons for failure to meet the M/WBE or SDVOBE goal, include, but are not limited to:

a. The M/WBE or SDVOBE was unable to provide performance and/or payment bonds.

b. The M/WBEs or SDVOBEs commercially reasonable bid was rejected based on price.

c. The M/WBE or SDVOBE would not agree to perform items of work at the unit bid price.

d The Contractor does not want to subcontract a percentage of the work sufficient to meet the goal.

e. Solicitation by mail or fax only.

XIII. COMPLIANCE

1. All activity performed by a M/WBE or SDVOBE for credit toward the Contract goal must be performed, managed and supervised by the M/WBE or SDVOBE. Prime Contractor shall not enter into, or condone, any other arrangement.

2. The Prime Contractor shall not perform with its own organization, or assign to any other business, any activity designated for the M/WBEs or SDVOBEs named on the Schedule submitted by the Prime Contractor under Section lX, or under Section XII(6), without the approval of the Department in accordance with the requirements of Sections XIII(6) and XIII(10).

3. The Department may suspend payment for any activity which was not performed by the M/WBE or SDVOBE to whom the activity was committed on the approved Schedule of Participation, or which was not performed in accordance with the requirements of Section XIII(I).

4. The Department retains the right to approve or disapprove all subcontractors. Requests by the Prime Contractor for approval of participation by a M/WBE or SDVOBE subcontractor for credit toward the Contract goal must include, in addition to any other requirements for subcontractor approval, the following:

a. A copy of the proposed subcontract. The subcontract must be for at least the dollar amount, and for the work described, in the Prime Contractor's Schedule of Participation.

b. A resume stating the qualifications and experience of the M/WBE or SDVOBE superintendent and/or foreperson who will supervise the on-site work. A new resume will be required for any change in supervisory personnel during the progress of the work.

c. A Schedule of Operations indicating when the M/WBE or SDVOBE is expected to perform the work.

d. A list of (1) equipment owned by the M/WBE or SDVOBE to be used on the Project, and (2) equipment to be leased by the M/WBE or SDVOBE for use on the Project.

e. A list of: (1) all projects (public and private) which the M/WBE or SDVOBE is currently performing, (2) all projects (public and private) to which the M/WBE or SDVOBE is committed, (3) all projects (public and private) to which the M/WBE or SDVOBE intends to make a commitment. For each contract, list the contracting organization. the name and telephone number of a contact person for the contracting organization, the dollar value of the work, a description of the work, and the M/WBEs or SDVOBEs work schedule for each project.

5. If, pursuant to the subcontractor approval process, the Department finds that a M WBE or SDVOBE subcontractor does not have sufficient experience or resources to perform, manage and supervise work of the kind proposed in accordance with the requirements of Section XIII(1), approval of the M/WBE or SDVOBE subcontractor may be denied ln the event of such denial, the Prime Contractor shall proceed in accordance with the requirements of Sections XIII(6) and XIII(10).

6. If, for reasons beyond its control, the Prime Contractor cannot comply with its M/WBE or SDVOBE commitment in accordance with the Schedule of participation submitted under Section lX and the terms of these Special Provisions, the Prime Contractor shall submit to the Department the reasons for its inability to comply with its obligations under Section I and shall submit, and request approval for, a revised Schedule of Participation. If approved by the Department, the revised Schedule shall govern the Prime Contractor's performance in meeting its obligations under these special provisions.

7. A Prime Contractor’s compliance with the participation goal in Section I shall be determined by reference to the required percentage of the total Contract price, including any additions and modifications thereto, provided, however, that no decrease in the dollar amount of a bidder’s commitment to any M/WBE or SDVOBE shall be allowed without the approval of the Department.

8. lf the Contract amount is increased, the Prime Contractor shall submit a revised 5chedule of Participation in accordance with Sections XIII(6) and XIII(10).

9. In the event of the desertification of a M/WBE or SDVOBE participating or scheduled to participate on the contract for credit toward the goal, the Contractor shall proceed in accordance with 5ections XIII(6) and XIII(10).

10. The Prime Contractor shall notify the Department immediately of any facts which come to its attention indicating that it may or will be unable to comply with any aspect of its M/WBE or SDVOBE obligation under lhis Contract.

11. Any notice required by these Special Provisions shall be given in writing to the Resident Engineer and the district designated Compliance Officer with a copy to the Director of Compliance, Office of Diversity and Civil Rights, 10 Park Plaza, Room 3170, Boston MA 02116.

12. The Prime Contractor and its subcontractors shall comply with the Department’s Electronic Reporting System Requirements (Contract Document 00821) and submit all information required by the Department related to the M/WBE Special Provisions and SDVOBE Special Provisions through the Equitable Business Opportunity Solution (EBO). The Department reserves the right to request reports in the format it deems necessary anytime during the performance of the Contract.

13. The Contractor shall pay each M/WBE or SDVOBE for satisfactory performance of its Contract no later than 10 days from receipt of payment for the work from the Department. Any delay or postponement of payment to the M/WBEs or SDVOBEs must be for good cause and only with the prior approval of the Department.

14. The Department may withhold the Contractor's next periodic payment if each M/WBE or S›DVOBE is not paid in accordance with Section XIII(13).

15. The Department may require specific performance of the Prime Contractor’s commitment under the Contract by requiring the Prime Contractor to subcontract with a M/WBE or SDVOBE for any contract or specialty item.

XIV. SANCTIONS

If the Prime Contractor does not comply with the terms of these Special Provisions and cannot demonstrate to the satisfaction of the Department that good faith efforts were made to achieve such compliance, the Department may, in addition to any other remedy provided for in the Contract, and notwithstanding any other provision in the Contract'

1. Retain, in connection with final acceptance and final payment, an amount determined by multiplying the total contract amount by the percentage in Section I, less the amount paid to approved M/WBEs or SDVOBEs for work performed under the Contract in accordance with the provisions of Section X. The Prime Contractor shall have the right to appeal such retention of funds in accordance with the provisions of M.G.L. c. 30A s.10.

2. Suspend, terminate or cancel this Contract, in whole or in part, and call upon the Prime Contractor's surety to perform all terms and conditions in the Contract.

3. In accordance with 720 CMR 5.05(1)(f), modify or revoke the Prime Contractor’s Prequalification status or recommend that the Prime Contractor not receive award of a pending Contract. The Prime Contractor may appeal the determination of the Prequalification Committee in accordance with the provisions of 720 CMR 5.07.

4. Initiate debarment proceedings under M.G.L. c.29 §29F.

XV. FURTHER INFORMATION

Any proposed M/WBE, SDVOBE, bidder, Contractor or subcontractor shall provide such information as is necessary in the judgement of the Department to ascertain its compliance with the terms of this Special Provision

XVI. LIST OF ADDITIONAL DOCUMENTS

1. The following documents shall be completed and signed by the bidder and designated M/WBEs or SDVOBEs in accordance with Section XII - Award Documentation and Procedures. These documents must be returned by the bidder to MassDOT’s Bid Document Distribution Center:

   □ Schedule of M/WBEs (Document B00842) or SDVOBE Participation (Document B00844)
   □ Letter of Intent: M/WBEs (Document B00843) or SDVOBE (Document B00845)
   □ M/WBEs or SDVOBE Joint Check Arrangement Approval Form (Document B00846), if Contractor and M/WBE or SDVOBE plan, or if M/WBE or SDVOBE is required to use a Joint Check (when applicable)

2. The following document shall be signed and returned by Contractor and Subcontractors/M/WBEs or SDVOBEs to the MassDOT District Office overseeing the Project, as applicable:

   □ Contractor/Subcontractor Certification Form (Document No. 00859) (a checklist of other documents to be included with every subcontract (M/WBEs or SDVOBEs and non-M/WBEs or SDVOBEs alike)).

3. The following document shall be provided to MassDOT’s Office of Civil Rights and Prequalification Office at least fourteen (14) business days before the bid opening date:

   □ Joint Venture Affidavit of M/WBE or SDVOBE/Non-M/WBE or Non-SDVOBE (Document B00847)

4. The following document shall be provided to MassDOT’s District Office of Civil Rights within 30 calendar days after the work of the DBE is completed, or no later than 30 calendar days after the work of the DBE is on a completed and processed CQE. This document shall be completed and submitted by the Prime Contractor:

   □ Certificate of Completion by a Minority Women or Disadvantaged Business Enterprise (M/W, DBE) (Form No. CSD-100)

*** END OF DOCUMENT ***

DOCUMENT 00761

SPECIAL PROVISIONS FOR CERTIFICATION REGARDING DEBARMENT, SUSPENSION, INELIGIBILITY AND VOLUNTARY EXCLUSION

Revised: 02/09/16

I. Instructions for Certification - Primary Covered Transactions:

By signing and submitting this proposal, the prospective primary participant is providing the certification set out below.

1. The inability of a person to provide the certification set out below will not necessarily result in denial of participation in this covered transaction. The prospective participant shall submit an explanation of why it cannot provide the certification set out below. The certification or explanation will be considered in connection with the MassDOT's determination whether to enter into this transaction. However, failure of the prospective primary participant to furnish a certification or an explanation shall disqualify such a person from participation in this transaction.

2. The certification in this clause is a material representation of fact upon which reliance was placed when the MassDOT determined to enter into this transaction. If it is later determined that the prospective primary participant knowingly rendered an erroneous certification, in addition to other remedies available, the MassDOT may terminate this transaction for cause of default.

3. The prospective primary participant shall provide immediate written notice to the MassDOT if any time the prospective primary participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances.

4. The terms "covered transaction," "debarred," "suspended," "ineligible," "lower tier covered transaction," "participant," "person," "primary covered transaction," "principal," "proposal," and "voluntarily excluded," as used in this clause, have the meanings set out in the Definitions and Coverage sections of rules implementing Executive Order 12549. You may contact the MassDOT for assistance in obtaining a copy of those regulations.

5. The prospective primary participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the MassDOT.

6. The prospective primary participant further agrees by submitting this proposal that it will include the clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion-Lower Tier Covered Transaction," provided by the MassDOT, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.

7. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may, but is not required to, check the nonprocurement portion of the "Lists of Parties Excluded From Federal Procurement or Nonprocurement Programs" (Nonprocurement List) which is compiled by the General Services Administration and the Debarment Lists compiled by both the Massachusetts Office of the Attorney General and the Department of Capital Asset Management and Maintenance (DCAMM) and published separately in the Central Register.

8. Nothing contained in the foregoing shall be construed to require establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

9. Except for transactions authorized under paragraph 5 of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, in addition to other remedies available, the MassDOT may terminate this transaction for cause or default.

* * * * *

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion -- Primary Covered Transactions

The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:

1. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal, State or local department or agency;

2. Have not within a 3-year period preceding this proposal been convicted of or had a civil judgement rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

3. Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph 2 of this certification; and

4. Have not within a 3-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

* * * * *

II. Instructions for Certification - Lower Tier Covered Transactions:

By signing and submitting this proposal, the prospective lower tier participant is providing the certification set out below.

1. The certification in this clause is a material representation of fact upon which reliance was placed when this transaction was entered into. If it is later determined that the prospective lower tier participant knowingly rendered an erroneous certification, in addition to other remedies available the MassDOT may pursue available remedies, including suspension and/or debarment.

2. The prospective lower tier participant shall provide immediate written notice to the person to which this proposal is submitted if at any time the prospective lower tier participant learns that its certification was erroneous by reason of changed circumstances.

3. The terms "covered transaction," "debarred," "suspended," "ineligible," "primary covered transaction," "participant," "person," "principal," "proposal," and "voluntarily excluded," as used in this clause, have the meanings set out in the Definitions and Coverage sections of rules implementing Executive Order 12549. You may contact the MassDOT for assistance in obtaining a copy of those regulations.

4. The prospective lower tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the MassDOT.

5. The prospective lower tier participant further agrees by submitting this proposal that it will include this clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion-Lower Tier Covered Transaction," without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.

6. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may, but is not required to, check the Nonprocurement List and the Debarment Lists.

7. Nothing contained in the foregoing shall be construed to require establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.

8. Except for transactions authorized under paragraph 4 of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, the MassDOT may pursue available remedies, including suspension and/or debarment.

* * * * *

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions

The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal, State or local department or agency.

Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

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DOCUMENT 00811

SPECIAL PROVISIONS
MONTHLY PRICE ADJUSTMENT FOR HOT MIX ASPHALT (HMA) MIXTURES
ENGLISH AND METRIC UNITS
Revised: 06/04/2019

This provision applies to all projects using greater than 100 tons (91 megagrams) of hot mix asphalt (HMA) mixtures containing liquid asphalt cement as stipulated in the Notice to Contractors section of the bid documents.

Price Adjustments will be based on the variance in price, for the liquid asphalt component only, between the Base Price and the Period Price. They shall not include transportation or other charges. Price Adjustments will occur on a monthly basis.

Base Price
The Base Price of liquid asphalt on a project as listed in the Notice to Contractors section of the bid documents is a fixed price determined by the Department at the time of the bid using the same method as the determination of the Period Price detailed below. The Base Price shall be used in all bids.

Period Price
The Period Price is the price of liquid asphalt for each monthly period as determined by the Department using the average selling price per standard ton of PG64-28 paving grade (primary binder classification) asphalt, FOB manufacturer's terminal, as listed under the "East Coast Market - New England, Boston, Massachusetts area" section of the Poten & Partners, Inc. "Asphalt Weekly Monitor". This average selling price is listed in the issue having a publication date of the second Friday of the month and will be posted as the Period Price for that month. The Department will post this Period Price on its website at https://www.mass.gov/service-details/2019-massdot-contract-price-adjustments within two (2) business days following its receipt of the relevant issue of the "Asphalt Weekly Monitor". Poten and Partners has granted the Department the right to publish this specific asphalt price information sourced from the Asphalt Weekly Monitor. This method of period price determination was formerly called the New Asphalt Period Price Method. Separate website postings using both the New Asphalt Period Price Method and the Old Asphalt Period Price Method were discontinued after June 2013.

Price Adjustment Determination, Calculation and Payment
The Contract Price of the HMA mixture will be paid under the respective item in the Contract. Price Adjustments, as herein provided, either upwards or downwards, will be made after the work has been performed using the monthly period price for the month during which the work was performed.

Price Adjustments will be paid only if the variance from the Base Price is 5% or more for a monthly period. The complete adjustment will be paid in all cases with no deduction of the 5% from either upward or downward adjustments.

The Price Adjustment applies only to the actual virgin liquid asphalt content in the mixture placed on the job in accordance with the Standard Specifications for Highways and Bridges, Division III, Section M3.11.03.

Price Adjustments will be separate payment items. The pay item numbers are 999.401 for a positive price adjustment (a payment) and 999.402 for a negative price adjustment (a deduction). Price Adjustments will be calculated using the following equation:

Price Adjustment = Tons of HMA Placed X Liquid Asphalt Content % X RAP Factor X (Period Price - Base Price)

No Price Adjustment will be allowed beyond the Completion Date of this Contract, unless there is a Department-approved extension of time.

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DOCUMENT 00812

SPECIAL PROVISIONS
MONTHLY PRICE ADJUSTMENT FOR DIESEL FUEL AND GASOLINE –
ENGLISH UNITS

Revised: 02/01/2021

This monthly fuel price adjustment is inserted in this contract because the national and worldwide energy situation has made the future cost of fuel unpredictable. This adjustment will provide for either additional compensation to the Contractor or repayment to the Commonwealth, depending on an increase or decrease in the average price of diesel fuel or gasoline.

This adjustment will be based on fuel usage factors for various items of work developed by the Highway Research Board in Circular 158, dated July 1974. These factors will be multiplied by the quantities of work done in each item during each monthly period and further multiplied by the variance in price from the Base Price to the Period Price.

The Base Price of Diesel Fuel and Gasoline will be the price as indicated in the Department's web site https://www.mass.gov/service-details/massdot-current-contract-price-adjustments for the month in which the contract was bid, which includes State Tax.

The Period Price will be the average of prices charged to the State, including State Tax for the bulk purchases made during each month.

This adjustment will be effected only if the variance from the Base Price is 5% or more for a monthly period. The complete adjustment will be paid in all cases with no deduction of the 5% from either upward or downward adjustments.

No adjustment will be paid for work done beyond the extended completion date of any contract.

Any adjustment (increase or decrease) to estimated quantities made to each item at the time of final payment will have the fuel price adjustment figured at the average period price for the entire term of the project for the difference of quantity.

The fuel price adjustment will apply only to the following items of work at the fuel factors shown:

ITEMS COVERED	**FUEL FACTORS**	
	Diesel	**Gasoline**
Excavation: and Borrow Work: Items 120, 120.1, 121, 123, 124, 125, 127, 129.3, 140, 140.1, 141, 142, 143, 144., 150, 150.1, 151 and 151.1 (Both Factors used)	0.29 Gallons / CY.	0.15 Gallons / CY
Surfacing Work: All Items containing Hot Mix Asphalt	2.90 Gallons / Ton	Does Not Apply

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DOCUMENT 00813

SPECIAL PROVISIONS

PRICE ADJUSTMENTS FOR STRUCTURAL STEEL AND REINFORCING STEEL

August 17, 2022

This special provision applies to all projects containing the use of structural steel and/or reinforcing steel as specified elsewhere in the Contract work. It applies to all structural steel and all reinforcing steel, as defined below, on the project. Compliance with this provision is mandatory, i.e., there are no “opt-in” or “opt-out” clauses. Price adjustments will be handled as described below and shall only apply to unfabricated reinforcing steel bars and unfabricated structural steel material, consisting of rolled shapes, plate steel, sheet piling, pipe piles, steel castings and steel forgings.

Price adjustments will be variances between Base Prices and Period Prices. Base Prices and Period Prices are defined below.

Price adjustments will only be made if the variances between Base Prices and Period Prices are 5% or more. A variance can result in the Period Price being either higher or lower than the Base Price. Once the 5% threshold has been achieved, the adjustment will apply to the full variance between the Base Price and the Period Price.

Price adjustments will be calculated by multiplying the number of pounds of unfabricated structural steel material or unfabricated reinforcing steel bars on a project by the index factor calculated as shown below under Example of a Period Price Calculation.

Price adjustments will *not* include guardrail panels or the costs of shop drawing preparation, handling, fabrication, coatings, transportation, storage, installation, profit, overhead, fuel costs, fuel surcharges, or other such charges not related to the cost of the unfabricated structural steel and unfabricated reinforcing steel.

The weight of steel subject to a price adjustment shall not exceed the final shipping weight of the fabricated part by more than 10%.

Base Prices and Period Prices are defined as follows:

Base Prices of unfabricated structural steel and unfabricated reinforcing steel on a project are fixed prices determined by the Department and found in the table below. While it is the intention of the Department to make this table comprehensive, some of a project’s unfabricated structural steel and/or unfabricated reinforcing steel may be inadvertently omitted. Should this occur, the Contractor shall bring the omission to the Department’s attention so that a contract alteration may be processed that adds the missing steel to the table and its price adjustments to the Contract.

The Base Price Date is the month and year in which MassDOT opened bids for the project. This date is used to select the Base Price Index.

Period Prices of unfabricated structural steel and unfabricated reinforcing steel on a project are variable prices that have been calculated using the Period Price Date and an index of steel prices to adjust the Base Price.

The Period Price Date is the date the steel was delivered to the fabricator as evidenced by an official bill of lading submitted to the Department containing a description of the shipped materials, weights of the shipped materials and the date of shipment. This date is used to select the Period Price Index.

The index used for the calculation of Period Prices is the U.S. Department of Labor Bureau of Labor Statistics Producer Price Index (PPI) Series ID WPU101702 (Not Seasonally Adjusted, Group: Metals and Metal Products, Item: Semi-finished Steel Mill Products.) As this index is subject to revision for a period of up to four (4) months after its original publication, no price adjustments will be made until the index for the period is finalized, i.e., the index is no longer suffixed with a “(P)”.

Period Prices are determined as follows:

Period Price = Base Price X Index Factor
Index Factor = Period Price Index / Base Price Index

Example of a Period Price Calculation:

Calculate the Period Price for December 2009 using a Base Price from March 2009 of $0.82/Pound for 1,000 Pounds of ASTM A709 (AASHTO M270) Grade A36 Structural Steel Plate.

The Period Price Date is December 2009. From the PPI website*, the Period Price Index = 218.0.

The Base Price Date is March 2009. From the PPI website*, the Base Price Index = 229.4.

Index Factor = Period Price Index / Base Price Index = 218.0 / 229.4 = 0.950
Period Price = Base Price X Index Factor = $0.82/Pound X 0.950 = $0.78/Pound

Since $0.82 - $0.78 = $0.04 is less than 5% of $0.82, no price adjustment is required.

If the $0.04 difference shown above was greater than 5% of the Base Price, then the price adjustment would be 1,000 Pounds X $0.04/Pound = $40.00. Since the Period Price of $0.78/Pound is less than the Base Price of $0.82/Pound, indicating a drop in the price of steel between the bid and the delivery of material, a credit of $40.00 would be owed to MassDOT. When the Period Price is higher than the Base Price, the price adjustment is owed to the Contractor.

* To access the PPI website and obtain a Base Price Index or a Period Price Index, go to
http://data.bls.gov/cgi-bin/srgate

End of example.

The Contractor will be paid for unfabricated structural steel and unfabricated reinforcing steel under the respective contract pay items for all components constructed of either structural steel or reinforced Portland cement concrete under their respective Contract Pay Items.

Price adjustments, as herein provided for, will be paid separately as follows:

Structural Steel
Pay Item Number 999.449 for positive (+) pay adjustments (payments to the Contractor)

Pay Item Number 999.457 for negative (-) pay adjustments (credits to MassDOT Highway Division)

Reinforcing Steel
Pay Item Number 999.466 for positive (+) pay adjustments (payments to the Contractor)

Pay Item Number 999.467 for negative (-) pay adjustments (credits to MassDOT Highway Division)

No price adjustment will be made for price changes after the Contract Completion Date, unless the MassDOT Highway Division has approved an extension of Contract Time for the Contract.

TABLE

Steel Type		Price per Pound
1	ASTM A615/A615M Grade 60 (AASHTO M31 Grade 60 or 420) Reinforcing Steel	$0.73
2	ASTM A27 (AASHTO M103) Steel Castings, H-Pile Points & Pipe Pile Shoes (See Note below.)	$1.02
3	ASTM A668 / A668M (AASHTO M102) Steel Forgings	$1.02
4	ASTM A108 (AASHTO M169) Steel Forgings for Shear Studs	$1.08
5	ASTM A709/A709M Grade 36 / AASHTO M270M/M270 Grade 36 or 250 Structural Steel Plate	$1.13
6	ASTM A709/A709M Grade 36 / AASHTO M270M/M270 Grade 36 or 250 Structural Steel Shapes	$1.06
7	ASTM A709/A709M Grade 50 / AASHTO M270M/M270 Grade 50 or 345 Structural Steel Plate	$1.13
8	ASTM A709/A709M Grade 50 / AASHTO M270M/M270 Grade 50 or 345 Structural Steel Shapes	$1.06
9	ASTM A709/A709M Grade 50WT / AASHTO M270M/M270 Grade 50WT or 345WT Structural Steel Plate	$1.17
10	ASTM A709/A709M Grade 50WT / AASHTO M270M/M270 Grade 50WT or 345W Structural Steel Shapes	$1.08
11	ASTM A709/A709M Grade 50W / AASHTO M270M/M270 Grade 50W 345W Structural Steel Plate	$1.17
12	ASTM A709/A709M Grade 50W / AASHTO M270M/M270 Grade 50W or 345W Structural Steel Shapes	$1.08
13	ASTM A709/A709M Grade HPS 50W / AASHTO M270M/M270 Grade HPS 50W or 345W Structural Steel Plate	$1.26
14	ASTM A709/A709M Grade HPS 70W / AASHTO M270M/M270 Grade HPS 70W or 485W Structural Steel Plate	$1.32
15	ASTM A514/A514M-05 Grade HPS 100W / AASHTO M270M/M270 Grade HPS 100W or 690W Structural Steel Plate	$2.01
16	ASTM A992/A992M Grade 50S / AASHTO M270M/M270 Grade 50S or 345S Structural Steel Plate	$1.17
17	ASTM A992/A992M Grade 50S / AASHTO M270M/M270 Grade 50S or 345S Structural Steel Shapes	$1.08
18	ASTM A276 Type 316 Stainless Steel	$6.00
19	ASTM A240 Type 316 Stainless Steel	$6.00
20	ASTM A148 Grade 80/50 Steel Castings (See Note below.)	$2.07
21	ASTM A53 Grade B Structural Steel Pipe	$1.33
22	ASTM A500 Grades A, B, 36 & 50 Structural Steel Pipe	$1.33
23	ASTM A252, Grades 240 (36 KSI) & 414 (60 KSI) Pipe Pile	$1.05
24	ASTM 252, Grade 2 Permanent Steel Casing	$1.05
25	ASTM A36 (AASHTO M183) for H-piles, steel supports and sign supports	$1.12
26	ASTM A328 / A328M, Grade 50 (AASHTO M202) Steel Sheetpiling	$1.97
27	ASTM A572 / A572M, Grade 50 Sheetpiling	$1.97
28	ASTM A36/36M, Grade 50	$1.13
29	ASTM A570, Grade 50	$1.12
30	ASTM A572 (AASHTO M223), Grade 50 H-Piles	$1.13
31	ASTM A1085 Grade A (50 KSI) Steel Hollow Structural Sections (HSS), heat-treated per ASTM A1085 Supplement S1	$1.33
32	AREA 140 LB Rail and Track Accessories	$0.67

NOTE: Steel Castings are generally used only on moveable bridges. Cast iron frames, grates and pipe are not “steel” castings and will not be considered for price adjustments.

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DOCUMENT 00814

SPECIAL PROVISIONS
PRICE ADJUSTMENT FOR PORTLAND CEMENT CONCRETE MIXES

January 12, 2009

This provision applies to all projects using greater than 100 Cubic Yards (76 Cubic Meters) of Portland cement concrete containing Portland cement as stipulated in the Notice to Contractors section of the Bid Documents. This Price Adjustment will occur on a monthly basis.

The Price Adjustment will be based on the variance in price for the Portland cement component only from the Base Price to the Period Price. It shall not include transportation or other charges.

The Base Price of Portland cement on a project is a fixed price determined at the time of bid by the Department by using the same method as for the determination of the Period Price (see below) and found in the Notice to Contractors.

The Period Price of Portland cement will be determined by using the latest published price, in dollars per ton (U.S.), for Portland cement (Type I) quoted for Boston, U.S.A. in the **Construction Economics** section of *ENR Engineering News-Record* magazine or at the ENR website http://www.enr.com under **Construction Economics**. The Period Price will be posted on the MassDOT website the Wednesday immediately following the publishing of the monthly price in ENR, which is normally the first week of the month.

The Contract Price of the Portland cement concrete mix will be paid under the respective item in the Contract. The price adjustment, as herein provided, upwards or downwards, will be made after the work has been performed, using the monthly period price for the month during which the work was performed.

The price adjustment applies only to the actual Portland cement content in the mix placed on the job in accordance with the Standard Specifications for Highways and Bridges, Division III, Section M4.02.01. No adjustments will be made for any cement replacement materials such as fly ash or ground granulated blast furnace slag.

The Price Adjustment will be a separate payment item. It will be determined by multiplying the number of cubic yards of Portland cement concrete placed during each monthly period times the Portland cement content percentage times the variance in price between the Base Price and Period Price of Portland cement.

This Price Adjustment will be paid only if the variance from the Base Price is 5% or more for a monthly period. The complete adjustment will be paid in all cases with no deduction of the 5% from either upward or downward adjustments.

No Price Adjustment will be allowed beyond the Completion Date of this Contract, unless there is a Department-approved extension of time.

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DOCUMENT 00820

THE COMMONWEALTH OF MASSACHUSETTS SUPPLEMENTAL EQUAL EMPLOYMENT OPPORTUNITY, NON-DISCRIMINATION AND AFFIRMATIVE ACTION PROGRAM

I. Definitions

For purposes of this contract,

"Minority" means a person who meets one or more of the following definitions:

(a) American Indian or Native American means: all persons having origins in any of the original peoples of North America and who are recognized as an Indian by a tribe or tribal organization.
(b) Asian means: All persons having origins in any of the original peoples of the Far East, Southeast Asia, the Indian sub-continent, or the Pacific Islands, including, but Not limited to China, Japan, Korea, Samoa, India, and the Philippine Islands.
(c) Black means: All persons having origins in any of the Black racial groups of Africa, including, but not limited to, African-Americans, and all persons having origins in any of the original peoples of the Cape Verdean Islands.
(d) Eskimo or Aleut means: All persons having origins in any of the peoples of Northern Canada, Greenland, Alaska, and Eastern Siberia.
(e) Hispanic means: All persons having their origins in any of the Spanish-speaking peoples of Mexico, Puerto Rico, Cuba, Central or South America, or the Caribbean Islands.

"State construction contract" means a contract for the construction, reconstruction, installation, demolition, maintenance or repair of a building or capital facility, or a contract for the construction, reconstruction, alteration, remodeling or repair of a public work undertaken by a department, agency, board, or commission of the commonwealth.

"State assisted construction contract" means a contract for the construction, reconstruction, installation, demolition, maintenance or repair of a building or capital facility undertaken by a political subdivision of the commonwealth, or two or more political subdivisions thereof, an authority, or other instrumentality and whose costs of the contract are paid for, reimbursed, grant funded, or otherwise supported, in whole or in part, by the commonwealth.

II. Equal Opportunity, Non-Discrimination and Affirmative Action

During the performance of this Contract, the Contractor and all subcontractors (hereinafter collectively referred to as "the Contractor") for a state construction contract or a state assisted construction contract, for him/herself, his/her assignees and successors in interest, agree to comply with all applicable equal employment opportunity, non-discrimination and affirmative action requirements, including but not limited to the following:

In connection with the performance of work under this contract, the Contractor shall not discriminate against any employee or applicant for employment because of race, color, religious creed, national origin, sex, sexual orientation, genetic information, military service, age, ancestry or disability, shall not discriminate in the selection or retention of subcontractors, and shall not discriminate in the procurement of materials and rentals of equipment.

The aforesaid provision shall include, but not be limited to, the following: employment upgrading, demotion, or transfer; recruitment advertising, layoff or termination; rates of pay or other forms of compensation; conditions or privileges of employment; and selection for apprenticeship or on-the-job training opportunity. The Contractor shall comply with the provisions of chapter 151B of the Massachusetts General Laws, as amended, and all other applicable anti-discrimination and equal opportunity laws, all of which are herein incorporated by reference and made a part of this Contract.

The Contractor shall post hereafter in conspicuous places, available for employees and applicants for employment, notices to be provided by the Massachusetts Commission Against Discrimination setting forth the provisions of the Fair Employment Practices Law of the Commonwealth (Massachusetts General Laws Chapter l51 B).

In connection with the performance of work under this contract, the Contractor shall undertake, in good faith, affirmative action measures to eliminate any discriminatory barriers in the terms and conditions of employment on the grounds of race, color, religious creed, national origin, sex, sexual orientation, genetic information, military service, age, ancestry or disability. Such affirmative action measures shall entail positive and aggressive measures to ensure nondiscrimination and to promote equal opportunity in the areas of hiring, upgrading, demotion or transfer, recruitment, layoff or termination, rate of compensation, apprenticeship and on-the-job training programs. A list of positive and aggressive measures shall include, but not be limited to, advertising employment opportunities in minority and other community news media; notifying minority, women and other community-based organizations of employment opportunities; validating all job specifications, selection requirements, and tests; maintaining a file of names and addresses of each worker referred to the Contractor and what action was taken concerning such worker; and notifying the administering agency in writing when a union with whom the Contractor has a collective bargaining agreement has failed to refer a minority or woman worker. These and other affirmative action measures shall include all actions required to guarantee equal employment opportunity for all persons, regardless of race, color, religious creed, national origin, sex, sexual orientation, genetic information, military service, age, ancestry or disability. One purpose of this provision is to ensure to the fullest extent possible an adequate supply of skilled tradesmen for this and future Commonwealth public construction projects.

III. Minority and Women Workforce Participation

Pursuant to his/her obligations under the preceding section, the Contractor shall strive to achieve on this project the labor participation goals contained herein. Said participation goals shall apply in each job category on this project including but not limited to bricklayers, carpenters, cement masons, electricians, ironworkers, operating engineers and those classes of work enumerated in Section 44F of Chapter 149 of the Massachusetts General Laws. The participation goals for this project shall be 15.3% for minorities and 6.9% for women. The participation goals, as set forth herein, shall not be construed as quotas or set-asides; rather, such participation goals will be used to measure the progress of the Commonwealth's equal opportunity, non-discrimination and affirmative action program. Additionally, the participation goals contained herein should not be seen or treated as a floor or as a ceiling for the employment of particular individuals or group of individuals.

IV. Liaison Committee

At the discretion of the agency that administers the contract for the construction project there may be established for the life of the contract a body to be known as the Liaison Committee. The Liaison Committee shall be composed of one representative each from the agency or agencies administering the contract for the construction project, hereinafter called the administering agency, a representative from the Office of Affirmative action, and such other representatives as may be designated by the administering agency. The Contractor (or his/her agent, if any, designated by him/her as the on-site equal employment opportunity officer) shall recognize the Liaison Committee as an affirmative action body, and shall establish a continuing working relationship with the Liaison Committee, consulting with the Liaison Committee on all matters related to minority recruitment, referral, employment and training.

V. Reports and Records

The Contractor shall prepare projected workforce tables on a quarterly basis when required by the administering agency. These shall be broken down into projections, by week, of workers required in each trade. Copies shall be furnished one week in advance of the commencement of the period covered, and also, when updated, to the administering agency and the Liaison Committee when required.

The Contractor shall prepare weekly reports in a form approved by the administering agency, unless information required is required to be reported electronically by the administering agency, the number of hours worked in each trade by each employee, identified as woman, minority, or non-minority. Copies of these shall be provided at the end of each such week to the administering agency and the Liaison Committee.

Records of employment referral orders, prepared by the Contractor, shall be made available to the administering agency on request.

The Contractor will provide all information and reports required by the administering agency on instructions issued by the administering agency and will permit access to its facilities and any books, records, accounts and other sources of information which may be determined by the administering agency to effect the employment of personnel. This provision shall apply only to information pertinent to the Commonwealth's supplementary non-discrimination, equal opportunity and access and opportunity contract requirements. Where information required is in the exclusive possession of another who fails or refuses to furnish this information, the Contractor shall so certify to the administering agency and shall set forth what efforts he has made to obtain the information.

VI. Access to Work Site

A designee of the administering agency and a designee of the Liaison Committee shall each have a right to access the work site.

VII. Solicitations for Subcontracts, and for the Procurement of Materials and Equipment

In all solicitations either by competitive bidding or negotiation made by the Contractor either for work to be performed under a subcontract or for the procurement of materials or equipment, each potential subcontractor or supplier shall be notified in writing by the Contractor of the Contractor's obligations under this contract relative to non-discrimination and equal opportunity.

VIII. Sanctions

Whenever the administering agency believes the General or Prime Contractor or any subcontractor may not be operating in compliance with the provisions of the Fair Employment Practices Law of the Commonwealth (Massachusetts General Laws Chapter 151B), the administering agency may refer the matter to the Massachusetts Commission Against Discrimination ("Commission") for investigation.

Following the referral of a matter by the administering agency to the Massachusetts Commission Against Discrimination, and while the matter is pending before the MCAD, the administering agency may withhold payments from contractors and subcontractors when it has documentation that the contractor or subcontractor has violated the Fair Employment Practices Law with respect to its activities on the Project, or if the administering agency determines that the contractor has materially failed to comply with its obligations and the requirements of this Section. The amount withheld shall not exceed a withhold of payment to the General or Prime Contractor of 1/100 or 1% of the contract award price or $5,000, whichever sum is greater, or, if a subcontractor is in non-compliance, a withhold by the administering agency from the General Contractor, to be assessed by the General Contractor as a charge against the subcontractor, of 1/100 or 1% of the subcontractor price, or $1,000 whichever sum is greater, for each violation of the applicable law or contract requirements. The total withheld from anyone General or Prime Contractor or subcontractor on a Project shall not exceed $20,000 overall. No withhold of payments or investigation by the Commission or its agent shall be initiated without the administering agency providing prior notice to the Contractor.

If, after investigation, the Massachusetts Commission Against Discrimination finds that a General or Prime Contractor or subcontractor, in commission of a state construction contract or state-assisted construction contract, violated the provisions of the Fair Employment Practices Law, the administering agency may convert the amount withheld as set forth above into a permanent sanction, as a permanent deduct from payments to the General or Prime Contractor or subcontractor, which sanction will be in addition to any such sanctions, fines or penalties imposed by the Massachusetts Commission Against Discrimination.

No sanction enumerated under this Section shall be imposed by the administering agency except after notice to the General or Prime Contractor or subcontractor and an adjudicatory proceeding, as that term is used, under Massachusetts General Laws Chapter 30A, has been conducted.

IX. Severability

The provisions of this section are severable, and if any of these provisions shall be held unconstitutional by any court of competent jurisdiction, the decision of such court shall not affect or impair any of the remaining provisions.

X. Contractor's Certification

After award and prior to the execution of any contract for a state construction contract or a state assisted construction contract, the Prime or General Contractor shall certify that it will comply with all provisions of this Document 00820 Supplemental Equal Employment Opportunity, Non-Discrimination and Affirmative Action Program, by executing Document 00859 Contractor/Subcontractor Certification Form.

XI. Subcontractor Requirements

Prior to the award of any subcontract for a state construction contract or a state assisted construction contract, the Prime or General Contractor shall provide all prospective subcontractors with a complete copy of this Document 00820 entitled "Supplemental Equal Employment Opportunity, Non-Discrimination and Affirmative Action Program" and will incorporate the provisions of this Document 00820 into any and all contracts or work orders for all subcontractors providing work on the Project. In order to ensure that the said subcontractor's certification becomes a part of all subcontracts under the prime contract, the Prime or General Contractor shall certify in writing to the administering agency that it has complied with the requirements as set forth in the preceeding paragraph by executing Document 00859 Contractor/Subcontractor Certification Form.

Rev'd 03/07/14

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DOCUMENT 00821

ELECTRONIC REPORTING REQUIREMENTS
CIVIL RIGHTS PROGRAMS AND CERTIFIED PAYROLL

Implemented on March 2, 2009 Revised June 04, 2019

The Massachusetts Department Of Transportation (MassDOT) has replaced the CHAMP reporting system with Equitable Business Opportunity Solution (EBO), a new web-based civil rights reporting software system. This system is capable of handling both civil rights reporting requirements and certified payrolls. The program's functions include the administration of Equal Employment Opportunity (EEO) requirements, On-The-Job Training requirements (OJT), Disadvantage Business Enterprise (DBE) and/or Minority / Women's Business Enterprise (M/WBE) subcontracting requirements, and the electronic collection of certified payrolls associated with MassDOT projects. In addition, this system is used to generate various data required as part of the American Recovery and Reinvestment Act (ARRA). Contractors are responsible for all coordination with all sub-contractors to ensure timely and accurate electronic submission of all required data.

Contractor and Sub-Contractor EBO User Certification

All contractors and sub-contractors must use the EBO software system. The software vendor, Internet Government Solutions (IGS), has developed an online EBO Training Module that is available to contractors and sub-contractors. This module is a self-tutorial which allows all users in the company to access the training, complete the tutorial, and become certified as EBO users for a one time fee of $75.00. This is the only cost to contractors and sub-contractors associated with the EBO software system. The online EBO Training Module can be accessed at www.ebotraining.com. Click the "Register My Company" button on the login page to begin your training registration. Questions regarding EBO online training should be directed to Gerry Anguilano, IGS at (440) 238-1684.

MassDOT will track contractors and sub-contractors who have successfully completed the on-line training module. All persons performing civil rights program and/or certified payroll functions should be EBO certified.

Vetting of Firms and Designated Firm Individuals

Contractors must authorize a Primary Log-In ID Holder who has completed EBO on-line training to have access to the EBO system by completing and submitting the "Request For EBO System Log-In/Password Form" located on the MassDOT website at: https://www.mass.gov/how-to/how-to-get-an-ebo-login
Contractors must also agree to comply with the EBO system user agreement located on the MassDOT website.

All subcontracts entered into on a project must include language that identifies the submission and training requirements that the sub-contractor must perform. Sub-contractors will be approved by the respective District Office of MassDOT through the existing approval process. When new sub-contractors, who have not previously worked for MassDOT, are initially selected by a general contractor, the new sub-contractor must be approved by the District before taking the EBO on-line training module.

Interim Reporting Requirements

Until MassDOT is satisfied that the EBO system is fully operational and functioning as designed, contractors and sub-contractors will be required to submit certified payrolls manually. There will be a transition period where dual reporting, through manual and electronic submission, will be required. MassDOT, however, will notify contractors and sub-contractors when they may cease manual submission of certified payrolls.

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DOCUMENT 00859

CONTRACTOR/SUBCONTRACTOR CERTIFICATION FORM ‡

The contractor shall submit this completed document 00859 to MassDOT for each subsontract.

________________________ **(Contractor)** **Date:**________________________

________________________ **(Subcontractor)** ☐ District Approved **S**ubcontractor

Contract No: 120593 **Project No.** 613045 **Federal Aid No.:** N/A

Location: LENOX AND LEE

Project Description: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line

PART 1 CONTRACTOR CERTIFICATION: I hereby certify, as an authorized official of this company, that to the best of my knowledge, information and belief, the company is in compliance with all applicable federal and state laws, rules, and regulations governing fair labor and employment practices, that the company will not discriminate in their employment practices, that the company will make good faith efforts to comply with the minority employee and women employee workforce participation ratio goals and specific affirmative action steps contained in Contract Document 00820 The Commonwealth of Massachusetts Supplemental Equal Employment Opportunity, Non-Discrimination and Affirmative Action Program, and that the company will comply with the special provisions and documentation indicated below (as checked).

I further hereby certify, as an authorized official of this company, that the special provisions and documentation indicated below (as checked) have been or are included in, and made part of, the Subcontractor Agreement entered into with the firm named above.

☐ **This is not a Federally-aided construction project**

Document #

☐ 00718 –Participation By Minority Or Women's Business Enterprises and SDVOBE†
☐ 00761 –Certification Regarding Debarment, Suspension, Ineligibility, and Voluntary Exclusion
☐ 00820 – MA Supplemental Equal Employment Opportunity, Non-Discrimination, and Affirmative Action Program
☐ 00821 – Electronic Reporting Requirements, Civil Rights Programs, and Certified Payroll
☐ 00859 – Contractor/Subcontractor Certification Form (this document)
☐ 00860 – MA Employment Laws
☐ 00861 – Applicable State Wage Rates in the Contract Proposal**
☐ B00842 – MA Schedule of Participation By Minority or Women Business Enterprises (M/WBEs)†
☐ B00843 – MA Letter of Intent – M/WBEs†

** Does not apply to Material Suppliers, unless performing work on-site
† Applies only if Subcontractor is a M/WBE; only include these forms for the particular M/WBE Entity

☐ B00844 - Schedule of Participation By SDVOBE
☐ B00845 - Letter of Intent – SDVOBE
☐ B00846 – M/WBE or SDVOBE Joint Check Arrangement Approval Form
☐ B00847 – Joint Venture Affidavit

☐ **This is a Federally-aided construction project (Federal Aid Number is present)**

Document #

☐ 00719 – Special Provisions for Participation by Disadvantaged Business Enterprises†
☐ 00760 - Form FHWA 1273 - Required Contract Provisions for Federal-Aid Construction Contracts
☐ 00820 – MA Supplemental Equal Employment Opportunity, Non-Discrimination and Affirmative Action Program
☐ 00821 – Electronic Reporting Requirements, Civil Rights Programs and Certified Payroll
☐ 00859 – Contractor/Subcontractor Certification Form (this document)
☐ 00860 – MA Employment Laws
☐ 00870 – Standard Federal Equal Employment Opportunity Construction Contract Specifications Executive Order 11246, (41 CFR Parts 60-4.2 and 60-4.3 (Solicitations and Equal Opportunity Clauses)*
☐ 00875 – Federal Trainee Special Provisions
☐ B00853 – Schedule of Participation by Disadvantaged Business Enterprise†

☐ B00854 – Letter of Intent – DBEs†
☐ B00855 – DBE Joint Check Arrangement Approval Form
☐ B00856 – Joint Venture Affidavit
☐ 00861/00880 - Applicable state and federal wage rates from Contract Proposal**

*****Applicable only to Contracts or Subcontracts in excess of $10,000
******Does not apply to Material Suppliers, unless performing work on-site
† Applies only if Subcontractor is a DBE; only include these forms for the particular DBE Entity

Signed this ________________ Day of __________________, 20_____ Under The Pains And Penalties Of Perjury.

_______________________________________ (Print Name and Title)

_______________________________________ (Authorized Signature)

PART 2

PART 2 SUBCONTRACTOR CERTIFICATION: I hereby certify, as an authorized official of this company, that the required documents in Part 1 above were physically incorporated in our Agreement/Subcontract with the Contractor and give assurance that this company will fully comply or make every good faith effort to comply with the same. I further certify that:

1. This company recognizes that if this is a Federal-Aid Project, then this Contract is covered by the equal employment opportunity laws administered and enforced by the United States Department of Labor ("USDOL"), Office of Federal Contract Compliance Programs ('OFCCP"). By signing below, we acknowledge that this company has certain reporting obligations to the OFCCP, as specified by 41 CFR Part 60-4.2.

2. This company further acknowledges that any contractor with fifty (50) or more employees on a Federal-aid Contract with a value of fifty-thousand ($50,000) dollars or more must annually file an EEO-1 Report (SF 100) to the EEOC, Joint Reporting Committee, on or before September 30th, each year, as specified by 41 CFR Part 60-1.7a.

3. For more information regarding the federal reporting requirements, please contact the USDOL, OFCCP Regional Office, at 1-646-264-3170 or EEO-1, Joint Reporting Committee at 1-866-286-6440. You may also find guidance at: http://www.dol.gov/ofccp/TAguides/consttag.pdf or http://www.wdol.gov/dba.aspx#0.

4. This company ☐ has, ☐ has not, participated in a previous contract or subcontract subject to the Equal Opportunity clauses set forth in 41 CFR Part 60-4 and Executive Order 11246, and where required, has filed with the Joint Reporting Committee, the Director of the Office of Federal Contract Compliance Programs or the EEO Commission all reports due under the applicable filing requirements.

5. This company is in full compliance with applicable Federal and Commonwealth of Massachusetts laws, rules, and regulations and is not currently debarred or disqualified from bidding on or participating in construction contracts in any jurisdiction of the United States. See : Contractors and Vendors Suspended or Debarred by MassDOT | Mass.gov.

6. This company is properly registered and in good standing with the Office of the Secretary of the Commonwealth.

Signed this ________ Day of ________________, 20_____, Under The Pains And Penalties Of Perjury.

Firm: ____________________________________
Address: ____________________________________
____
____
Telephone Number:____________________________
Federal I.D. Number:__________________________
Estimated Start Date:__________________________
Estimated Completion Date:_____________________
Estimated Dollar Amount:_______________________

_______________________________________ (Print Name and Title)

_______________________________________ (Authorized Signature)

_______________________________________ (Date)

Rev'd 06/03/14

*** END OF DOCUMENT ***

DOCUMENT 00860

COMMONWEALTH OF MASSACHUSETTS PUBLIC EMPLOYMENT LAWS

Revised February 20, 2019

The Contractor's attention is directed to Massachusetts General Laws, Chapter 149, Sections 26 through 27H, and 150A. This contract is considered to fall within the ambit of that law, which provides that in general, the Prevailing Rate or Total Rate must be paid to employees working on projects funded by the Commonwealth of Massachusetts or any political subdivision including Massachusetts Department of Transportation (MassDOT).

A Federal Aid project is also subject to the Federal Minimum Wage Rate law for construction. When comparing a state minimum wage rate, monitored by the Massachusetts Attorney General, versus federal minimum wage rate, monitored by the U.S. Department of Labor Wage and Hour Division, for a particular job classification the higher wage is at all times to be paid to the affected employee.

Every contractor or subcontractor engaged in this contract to which sections twenty-seven and twenty-seven A apply will keep a true and accurate record of all mechanics and apprentices, teamsters, chauffeurs and laborers employed thereon, showing the name, address and occupational classification of each such employee on this contract, and the hours worked by, and the wages paid to, each such employee, and shall furnish to the MassDOT's Resident Engineer, on a weekly basis, a copy of said record, in a form approved by MassDOT and in accordance with M.G.L. c. 149, § 27B, signed by the employer or his/her authorized agent under the penalties of perjury.

Each such contractor or subcontractor shall preserve its payroll records for a period of three years from the date of completion of the contract.

The Prevailing Wage Rate generally includes the following:

> Minimum Hourly Wage + Employer Contributions to Benefit Plans = Prevailing Wage Rate or Total Rate
>
> Any employer who does not make contributions to Benefit Plans must pay the total Prevailing Wage Rate directly to the employee.

Any deduction from the Prevailing Wage Rate or Total Rate for contributions to benefit plans can only be for a Health & Welfare, Pension, or Supplementary Unemployment plan meeting the requirements of the Employee Retirement Income Security Act (ERISA) of 1974. The maximum allowable deduction for these benefits from the prevailing wage rate cannot be greater than the amount allowed by Executive Office of Labor (EOL) for the specified benefits. Any additional expense of providing benefits to the employees is to be borne by the employer and cannot be deducted from the Minimum Hourly Wage. If the employer's benefit expense is less than that so provided by EOL the difference will be paid directly to the employee. The rate established must be paid to all employees who perform work on the project.

When an employer makes deductions from the Minimum Hourly Wage for an employee's contribution to social security, state taxes, federal taxes, and/or other contribution programs, allowed by law, the employer shall furnish each employee a suitable pay slip, check stub or envelope notifying the employee of the amount of the deductions.

No contractor or subcontractor contracting for any part of the contract week shall require or permit any laborer or mechanic to be employed on such work in excess of forty hours in any workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times his basic rate of pay for all hours worked in excess of forty hours in such workweek, whichever is the greater number of overtime hours.

Apprentice Rates are permitted only when there is an Apprentice Agreement registered with the Massachusetts Division of Apprentice Training in accordance with M.G.L. c. 23, § 11E-11L.

The Prevailing Wage Rates issued for each project shall be the rates paid for the entire project. The Prevailing Wage Rates must be posted on the job site at all times and be visible from a public way.

In addition, each such contractor and subcontractor shall furnish to the MassDOT's Resident Engineer, within fifteen days after completion of its portion of the work, a statement, executed by the contractor or subcontractor or by any authorized officer or employee of the contractor or subcontractor who supervises the payment of wages, in the following form:

STATEMENT OF COMPLIANCE

Date: ___________________

I , ____do hereby state:
(Name of signatory party) (Title)

That I pay or supervise the payment of the persons employed by:

____
(Contractor or Subcontractor)

on the ____
(MassDOT Project Location and Contract Number)

and that all mechanics and apprentices, teamsters, chauffeurs and laborers employed on said project have been paid in accordance with wages determined under the provisions of sections twenty-six and twenty-seven of chapter one hundred and forty-nine of the General Laws.

Signature ____

Title ____

The above-mentioned copies of payroll records and statements of compliance shall be available for inspection by any interested party filing a written request to the MassDOT's Resident Engineer for such inspection and copying.

Massachusetts General Laws c. 149, §27, requires annual updates to prevailing wage schedules for all public construction contracts lasting longer than one year. MassDOT will request the required updates and furnish them to the Contractor. The Contractor is required to pay no less than the wage rates indicated on the annual updated wage schedules.

MassDOT will request the updates no later that two week before the anniversary of the Notice to Proceed date of the contract to allow for adequate processing by the Department of Labor Standards (DLS). The effective date for the new rates will be the anniversary date of the contract (i.e. the notice to proceed date), regardless of the date of issuance on the schedule from DLS.

All bidders are cautioned that the aforementioned laws require that employers pay to covered employees no less than the applicable minimum wages. In addition, the same laws require that the applicable prevailing wages become incorporated as part of this contract. The prevailing minimum wage law establishes serious civil and criminal penalties for violations, including imprisonment and exclusion from future public contracts. Bidders are cautioned to carefully read the relevant sections of the Massachusetts General Laws.

*** END OF DOCUMENT ***

DOCUMENT 00861

STATE WAGE RATES

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF LABOR AND WORKFORCE DEVELOPMENT
DEPARTMENT OF LABOR STANDARDS

Prevailing Wage Rates

As determined by the Director under the provisions of the Massachusetts General Laws, Chapter 149, Sections 26 to 27H

CHARLES D. BAKER
Governor

KARYN E. POLITO
Lt. Governor

ROSALIN ACOSTA
Secretary

MICHAEL FLANAGAN
Director

Awarding Authority: MassDOT Rail and Transit

Contract Number: 120593 **City/Town:** LEE

Description of Work: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line. Replacement of two railroad bridges, track work at bridge approaches and wetland mitigation

Job Location: Lenox and Lee

Information about Prevailing Wage Schedules for Awarding Authorities and Contractors

- **The wage rates will remain in effect for the duration of the project, except in the case of multi-year public construction projects. For construction projects lasting longer than one year, awarding authorities must request an updated wage schedule no later than two weeks before the anniversary of the date the contract was executed by the awarding authority and the general contractor.** For multi-year CM AT RISK projects, the awarding authority must request an annual update no later than two weeks before the anniversary date, determined as the earlier of: (a) the execution date of the GMP Amendment, or (b) the execution date of the first amendment to permit procurement of construction services. The annual update requirement is not applicable to 27F “rental of equipment” contracts. **The updated wage schedule must be provided to all contractors, including general and sub-contractors, working on the construction project.**
- This wage schedule applies only to the specific project referenced at the top of this page and uniquely identified by the “Wage Request Number” on all pages of this schedule.
- An Awarding Authority must request an updated wage schedule if it has not opened bids or selected a contractor within 90 days of the date of issuance of the wage schedule. For CM AT RISK projects (bid pursuant to G.L. c.149A), the earlier of: (a) the execution date of the GMP Amendment, or (b) the bid for the first construction scope of work must be within 90-days of the wage schedule issuance date.
- The wage schedule shall be incorporated in any advertisement or call for bids for the project as required by M.G.L. c. 149, § 27. The wage schedule shall be made a part of the contract awarded for the project. The wage schedule must be posted in a conspicuous place at the work site for the life of the project in accordance with M.G.L. c. 149 § 27. The wages listed on the wage schedule must be paid to employees performing construction work on the project whether they are employed by the prime contractor, a filed sub-bidder, or a sub-contractor.
- Apprentices working on the project are required to be registered with the Massachusetts Division of Apprentice Standards (DAS). Apprentices must keep their apprentice identification card on their persons during all work hours on the project. An apprentice registered with DAS may be paid the lower apprentice wage rate at the applicable step as provided on the prevailing wage schedule. **Any apprentice not registered with DAS regardless of whether they are registered with another federal, state, local, or private agency must be paid the journeyworker's rate.**
- Every contractor or subcontractor working on the construction project must submit weekly payroll reports and a Statement of Compliance directly to the awarding authority by mail or email and keep them on file for three years. Each weekly payroll report must contain: the employee’s name, address, occupational classification, hours worked, and wages paid. Do not submit weekly payroll reports to DLS. For a sample payroll reporting form go to http://www.mass.gov/dols/pw.
- Contractors with questions about the wage rates or classifications included on the wage schedule have an affirmative obligation to inquire with DLS at (617) 626-6953.
- Contractors must obtain the wage schedules from awarding authorities. Failure of a contractor or subcontractor to pay the prevailing wage rates listed on the wage schedule to all employees who perform construction work on the project is a violation of the law and subjects the contractor or subcontractor to civil and criminal penalties.
- Employees not receiving the prevailing wage rate set forth on the wage schedule may file a complaint with the Fair Labor Division of the office of the Attorney General at (617) 727-3465.

Classification Construction	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
(2 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$35.95	$13.41	$16.01	$0.00	$65.37
(3 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.02	$13.41	$16.01	$0.00	$65.44
(4 & 5 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.14	$13.41	$16.01	$0.00	$65.56
ADS/SUBMERSIBLE PILOT *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$103.05	$9.40	$23.12	$0.00	$135.57
For apprentice rates see "Apprentice- PILE DRIVER"						
AIR TRACK OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.23	$9.10	$13.62	$0.00	$52.95
	12/01/2022	$31.04	$9.10	$13.62	$0.00	$53.76
	06/01/2023	$31.86	$9.10	$13.62	$0.00	$54.58
	12/01/2023	$32.67	$9.10	$13.62	$0.00	$55.39
	06/01/2024	$33.49	$9.10	$13.62	$0.00	$56.21
	12/01/2024	$34.30	$9.10	$13.62	$0.00	$57.02
For apprentice rates see "Apprentice- LABORER"						
AIR TRACK OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
ASBESTOS WORKER (PIPES & TANKS) *HEAT & FROST INSULATORS LOCAL 6 (SPRINGFIELD)*	12/01/2020	$34.29	$12.80	$8.95	$0.00	$56.04
ASPHALT RAKER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
ASPHALT RAKER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
AUTOMATIC GRADER-EXCAVATOR (RECLAIMER) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BACKHOE/FRONT-END LOADER OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BARCO-TYPE JUMPING TAMPER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
BATCH/CEMENT PLANT - ON SITE *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BLOCK PAVER, RAMMER / CURB SETTER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.23	$9.10	$13.62	$0.00	$52.95
	12/01/2022	$31.04	$9.10	$13.62	$0.00	$53.76
	06/01/2023	$31.86	$9.10	$13.62	$0.00	$54.58
	12/01/2023	$32.67	$9.10	$13.62	$0.00	$55.39
	06/01/2024	$33.49	$9.10	$13.62	$0.00	$56.21
	12/01/2024	$34.30	$9.10	$13.62	$0.00	$57.02
For apprentice rates see "Apprentice- LABORER"						
BLOCK PAVER, RAMMER / CURB SETTER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
BOILER MAKER *BOILERMAKERS LOCAL 29*	01/01/2020	$46.10	$7.07	$17.98	$0.00	$71.15

Apprentice - *BOILERMAKER - Local 29*

Effective Date - 01/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	65	$29.97	$7.07	$11.69	$0.00	$48.73
2	65	$29.97	$7.07	$11.69	$0.00	$48.73
3	70	$32.27	$7.07	$12.59	$0.00	$51.93
4	75	$34.58	$7.07	$13.49	$0.00	$55.14
5	80	$36.88	$7.07	$14.38	$0.00	$58.33
6	85	$39.19	$7.07	$15.29	$0.00	$61.55
7	90	$41.49	$7.07	$16.18	$0.00	$64.74
8	95	$43.80	$7.07	$17.09	$0.00	$67.96

Notes:

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
BRICK/STONE/ARTIFICIAL MASONRY (INCL. MASONRY WATERPROOFING) *BRICKLAYERS LOCAL 3 (SPRINGFIELD/PITTSFIELD)*	08/01/2022	$47.56	$11.49	$20.37	$0.00	$79.42
	02/01/2023	$48.76	$11.49	$20.37	$0.00	$80.62
	08/01/2023	$50.81	$11.49	$20.37	$0.00	$82.67
	02/01/2024	$52.06	$11.49	$20.37	$0.00	$83.92
	08/01/2024	$53.31	$11.49	$20.37	$0.00	$85.17
	02/01/2025	$54.61	$11.49	$20.37	$0.00	$86.47
	08/01/2025	$56.76	$11.49	$20.37	$0.00	$88.62
	02/01/2026	$58.11	$11.49	$20.37	$0.00	$89.97
	08/01/2026	$60.31	$11.49	$20.37	$0.00	$92.17
	02/01/2027	$61.71	$11.49	$20.37	$0.00	$93.57

Apprentice - *BRICK/PLASTER/CEMENT MASON - Local 3 Springfield/Pittsfield*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$23.78	$11.49	$20.37	$0.00	$55.64
2	60	$28.54	$11.49	$20.37	$0.00	$60.40
3	70	$33.29	$11.49	$20.37	$0.00	$65.15
4	80	$38.05	$11.49	$20.37	$0.00	$69.91
5	90	$42.80	$11.49	$20.37	$0.00	$74.66

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$24.38	$11.49	$20.37	$0.00	$56.24
2	60	$29.26	$11.49	$20.37	$0.00	$61.12
3	70	$34.13	$11.49	$20.37	$0.00	$65.99
4	80	$39.01	$11.49	$20.37	$0.00	$70.87
5	90	$43.88	$11.49	$20.37	$0.00	$75.74

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
BULLDOZER/POWER SHOVEL/TREE SHREDDER /CLAM SHELL *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
CAISSON & UNDERPINNING BOTTOM MAN *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$42.33	$9.10	$17.72	$0.00	$69.15
For apprentice rates see "Apprentice- LABORER"						
CAISSON & UNDERPINNING LABORER *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
For apprentice rates see "Apprentice- LABORER"						
CAISSON & UNDERPINNING TOP MAN *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
For apprentice rates see "Apprentice- LABORER"						
CARBIDE CORE DRILL OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
CARPENTER *CARPENTERS LOCAL 336 - BERKSHIRE COUNTY*	09/01/2022	$39.82	$7.16	$18.15	$0.00	$65.13
	03/01/2023	$40.32	$7.16	$18.15	$0.00	$65.63

Apprentice - *CARPENTER - Local 336 Berkshire*

Effective Date - 09/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.91	$7.16	$1.40	$0.00	$28.47
2	60	$23.89	$7.16	$1.40	$0.00	$32.45
3	70	$27.87	$7.16	$13.95	$0.00	$48.98
4	75	$29.87	$7.16	$13.95	$0.00	$50.98
5	80	$31.86	$7.16	$15.35	$0.00	$54.37
6	80	$31.86	$7.16	$15.35	$0.00	$54.37
7	90	$35.84	$7.16	$16.75	$0.00	$59.75
8	90	$35.84	$7.16	$16.75	$0.00	$59.75

Effective Date - 03/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$20.16	$7.16	$1.40	$0.00	$28.72
2	60	$24.19	$7.16	$1.40	$0.00	$32.75
3	70	$28.22	$7.16	$13.95	$0.00	$49.33
4	75	$30.24	$7.16	$13.95	$0.00	$51.35
5	80	$32.26	$7.16	$15.35	$0.00	$54.77
6	80	$32.26	$7.16	$15.35	$0.00	$54.77
7	90	$36.29	$7.16	$16.75	$0.00	$60.20
8	90	$36.29	$7.16	$16.75	$0.00	$60.20

Notes:

% Indentured After 10/1/17; 45/45/55/55/70/70/80/80
Step 1&2 $26.70/ 3&4 43.29/ 5&6 50.73/ 7&8 $56.17

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CARPENTER WOOD FRAME *CARPENTERS-ZONE 3 (Wood Frame)* All Aspects of New Wood Frame Work	04/01/2022	$23.66	$7.21	$4.80	$0.00	$35.67
	04/01/2023	$24.16	$7.21	$4.80	$0.00	$36.17

Apprentice - *CARPENTER (Wood Frame) - Zone 3*

Effective Date - 04/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$14.20	$7.21	$0.00	$0.00	$21.41
2	60	$14.20	$7.21	$0.00	$0.00	$21.41
3	65	$15.38	$7.21	$0.00	$0.00	$22.59
4	70	$16.56	$7.21	$0.00	$0.00	$23.77
5	75	$17.75	$7.21	$3.80	$0.00	$28.76
6	80	$18.93	$7.21	$3.80	$0.00	$29.94
7	85	$20.11	$7.21	$3.80	$0.00	$31.12
8	90	$21.29	$7.21	$3.80	$0.00	$32.30

Effective Date - 04/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$14.50	$7.21	$0.00	$0.00	$21.71
2	60	$14.50	$7.21	$0.00	$0.00	$21.71
3	65	$15.70	$7.21	$0.00	$0.00	$22.91
4	70	$16.91	$7.21	$0.00	$0.00	$24.12
5	75	$18.12	$7.21	$3.80	$0.00	$29.13
6	80	$19.33	$7.21	$3.80	$0.00	$30.34
7	85	$20.54	$7.21	$3.80	$0.00	$31.55
8	90	$21.74	$7.21	$3.80	$0.00	$32.75

Notes:

% Indentured After 10/1/17; 45/45/55/55/70/70/80/80

Step 1&2 $17.86/ 3&4 $20.22/ 5&6 $27.57/ 7&8 $29.94

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CEMENT MASONRY/PLASTERING *BRICKLAYERS LOCAL 3 (SPRINGFIELD/PITTSFIELD)*	01/01/2020	$41.94	$12.70	$17.64	$0.62	$72.90

Apprentice - *CEMENT MASONRY/PLASTERING - Springfield/Pittsfield*

Effective Date - 01/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$20.97	$12.70	$15.41	$0.00	$49.08
2	60	$25.16	$12.70	$17.64	$0.62	$56.12
3	65	$27.26	$12.70	$17.64	$0.62	$58.22
4	70	$29.36	$12.70	$17.64	$0.62	$60.32
5	75	$31.46	$12.70	$17.64	$0.62	$62.42
6	80	$33.55	$12.70	$17.64	$0.62	$64.51
7	90	$37.75	$12.70	$17.64	$0.62	$68.71

Notes:

Steps 3,4 are 500 hrs. All other steps are 1,000 hrs.

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CHAIN SAW OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
COMPRESSOR OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
CRANE OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$42.24	$12.47	$14.50	$0.00	$69.21
	12/01/2022	$43.12	$12.47	$14.50	$0.00	$70.09
	06/01/2023	$44.07	$12.47	$14.50	$0.00	$71.04
	12/01/2023	$45.02	$12.47	$14.50	$0.00	$71.99
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
DELEADER (BRIDGE) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$54.86	$8.65	$23.05	$0.00	$86.56
	01/01/2023	$56.06	$8.65	$23.05	$0.00	$87.76
	07/01/2023	$57.26	$8.65	$23.05	$0.00	$88.96
	01/01/2024	$58.46	$8.65	$23.05	$0.00	$90.16
	07/01/2024	$59.66	$8.65	$23.05	$0.00	$91.36
	01/01/2025	$60.86	$8.65	$23.05	$0.00	$92.56

Apprentice - *PAINTER Local 35 - BRIDGES/TANKS*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$27.43	$8.65	$0.00	$0.00	$36.08
2	55	$30.17	$8.65	$6.27	$0.00	$45.09
3	60	$32.92	$8.65	$6.84	$0.00	$48.41
4	65	$35.66	$8.65	$7.41	$0.00	$51.72
5	70	$38.40	$8.65	$19.63	$0.00	$66.68
6	75	$41.15	$8.65	$20.20	$0.00	$70.00
7	80	$43.89	$8.65	$20.77	$0.00	$73.31
8	90	$49.37	$8.65	$21.91	$0.00	$79.93

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$28.03	$8.65	$0.00	$0.00	$36.68
2	55	$30.83	$8.65	$6.27	$0.00	$45.75
3	60	$33.64	$8.65	$6.84	$0.00	$49.13
4	65	$36.44	$8.65	$7.41	$0.00	$52.50
5	70	$39.24	$8.65	$19.63	$0.00	$67.52
6	75	$42.05	$8.65	$20.20	$0.00	$70.90
7	80	$44.85	$8.65	$20.77	$0.00	$74.27
8	90	$50.45	$8.65	$21.91	$0.00	$81.01

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
DEMO: ADZEMAN *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$42.33	$9.10	$17.57	$0.00	$69.00
	12/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	06/01/2023	$44.33	$9.10	$17.57	$0.00	$71.00
	12/01/2023	$45.58	$9.10	$17.57	$0.00	$72.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: BACKHOE/LOADER/HAMMER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	12/01/2022	$44.33	$9.10	$17.57	$0.00	$71.00
	06/01/2023	$45.33	$9.10	$17.57	$0.00	$72.00
	12/01/2023	$46.58	$9.10	$17.57	$0.00	$73.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: BURNERS *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.08	$9.10	$17.57	$0.00	$69.75
	12/01/2022	$44.08	$9.10	$17.57	$0.00	$70.75
	06/01/2023	$45.08	$9.10	$17.57	$0.00	$71.75
	12/01/2023	$46.33	$9.10	$17.57	$0.00	$73.00
For apprentice rates see "Apprentice- LABORER"						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
DEMO: CONCRETE CUTTER/SAWYER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	12/01/2022	$44.33	$9.10	$17.57	$0.00	$71.00
	06/01/2023	$45.33	$9.10	$17.57	$0.00	$72.00
	12/01/2023	$46.58	$9.10	$17.57	$0.00	$73.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: JACKHAMMER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.08	$9.10	$17.57	$0.00	$69.75
	12/01/2022	$44.08	$9.10	$17.57	$0.00	$70.75
	06/01/2023	$45.08	$9.10	$17.57	$0.00	$71.75
	12/01/2023	$46.33	$9.10	$17.57	$0.00	$73.00
For apprentice rates see "Apprentice- LABORER"						
DEMO: WRECKING LABORER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$42.33	$9.10	$17.57	$0.00	$69.00
	12/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	06/01/2023	$44.33	$9.10	$17.57	$0.00	$71.00
	12/01/2023	$45.58	$9.10	$17.57	$0.00	$72.25
For apprentice rates see "Apprentice- LABORER"						
DIVER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$68.70	$9.40	$23.12	$0.00	$101.22
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER TENDER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$49.07	$9.40	$23.12	$0.00	$81.59
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER TENDER (EFFLUENT) *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$73.60	$9.40	$23.12	$0.00	$106.12
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER/SLURRY (EFFLUENT) *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$103.05	$9.40	$23.12	$0.00	$135.57
For apprentice rates see "Apprentice- PILE DRIVER"						
DRAWBRIDGE OPERATOR (Construction) *DRAWBRIDGE - SEIU LOCAL 888*	07/01/2020	$26.77	$6.67	$3.93	$0.16	$37.53
ELECTRICIAN (Including Core Drilling) *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47

Apprentice - *ELECTRICIAN - Local 7*

Effective Date - 07/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.56	$7.35	$0.56	$0.00	$26.47
2	45	$20.88	$7.35	$0.63	$0.00	$28.86
3	50	$23.21	$12.25	$7.20	$0.00	$42.66
4	55	$25.53	$12.25	$7.27	$0.00	$45.05
5	65	$30.17	$12.25	$9.14	$0.00	$51.56
6	70	$32.49	$12.25	$10.37	$0.00	$55.11

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.80	$7.50	$0.56	$0.00	$26.86
2	45	$21.15	$7.50	$0.63	$0.00	$29.28
3	50	$23.51	$12.50	$7.26	$0.00	$43.27
4	55	$25.86	$12.50	$7.33	$0.00	$45.69
5	65	$30.56	$12.50	$9.27	$0.00	$52.33
6	70	$32.91	$12.50	$10.54	$0.00	$55.95

Notes:

Steps 1-2 are 1000 hrs; Steps 3-6 are 1500 hrs.

Apprentice to Journeyworker Ratio:2:3**

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ELEVATOR CONSTRUCTOR *ELEVATOR CONSTRUCTORS LOCAL 41*	01/01/2022	$58.62	$16.03	$20.21	$0.00	$94.86

Apprentice - *ELEVATOR CONSTRUCTOR - Local 41*

Effective Date - 01/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.31	$16.03	$0.00	$0.00	$45.34
2	55	$32.24	$16.03	$20.21	$0.00	$68.48
3	65	$38.10	$16.03	$20.21	$0.00	$74.34
4	70	$41.03	$16.03	$20.21	$0.00	$77.27
5	80	$46.90	$16.03	$20.21	$0.00	$83.14

Notes:

Steps 1-2 are 6 mos.; Steps 3-5 are 1 year

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ELEVATOR CONSTRUCTOR HELPER *ELEVATOR CONSTRUCTORS LOCAL 41*	01/01/2022	$41.03	$16.03	$20.21	$0.00	$77.27

For apprentice rates see "Apprentice - ELEVATOR CONSTRUCTOR"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FENCE & BEAM RAIL ERECTOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
FENCE & GUARD RAIL ERECTOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)"						
FIELD ENG.INST/ROD-BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$18.84	$4.80	$4.10	$0.00	$27.74
FIELD ENG.PARTY CHIEF:BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$21.33	$4.80	$4.10	$0.00	$30.23
FIELD ENG.SURVEY CHIEF-BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$22.33	$4.80	$4.10	$0.00	$31.23
FIRE ALARM INSTALLER *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- ELECTRICIAN"						
FIRE ALARM REPAIR / MAINTENANCE / COMMISSIONING *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- TELECOMMUNICATIONS TECHNICIAN"						
FIREMAN *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96

Apprentice - *OPERATING ENGINEERS - Local 98 Class 3*

Effective Date - 06/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$22.93	$12.47	$14.50	$0.00	$49.90
2	70	$26.75	$12.47	$14.50	$0.00	$53.72
3	80	$30.57	$12.47	$14.50	$0.00	$57.54
4	90	$34.39	$12.47	$14.50	$0.00	$61.36

Effective Date - 12/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$23.45	$12.47	$14.50	$0.00	$50.42
2	70	$27.36	$12.47	$14.50	$0.00	$54.33
3	80	$31.27	$12.47	$14.50	$0.00	$58.24
4	90	$35.18	$12.47	$14.50	$0.00	$62.15

Notes:

Steps 1-2 are 1000 hrs.; Steps 3-4 are 2000 hrs.

Apprentice to Journeyworker Ratio:1:6

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FLAGGER & SIGNALER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$24.50	$9.10	$14.69	$0.00	$48.29

For apprentice rates see "Apprentice- LABORER (Heavy and Highway)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FLOORCOVERER *FLOORCOVERERS LOCAL 2168 ZONE III*	03/01/2022	$39.22	$7.16	$18.15	$0.00	$64.53

Apprentice - *FLOORCOVERER - Local 2168 Zone III*

Effective Date - 03/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.61	$7.16	$1.40	$0.00	$28.17
2	55	$21.57	$7.16	$1.40	$0.00	$30.13
3	60	$23.53	$7.16	$13.95	$0.00	$44.64
4	65	$25.49	$7.16	$13.95	$0.00	$46.60
5	70	$27.45	$7.16	$15.35	$0.00	$49.96
6	75	$29.42	$7.16	$15.35	$0.00	$51.93
7	80	$31.38	$7.16	$16.75	$0.00	$55.29
8	85	$33.34	$7.16	$16.75	$0.00	$57.25

Notes: Steps are 750 hrs.
% After 10/1/17; 45/45/55/55/70/70/80/80 (1500hr Steps)
Step 1&2 $26.21/ 3&4 $31.49/ 5&6 $49.96/ 7&8 $55.29

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FORK LIFT *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.43	$12.47	$14.50	$0.00	$65.40
	12/01/2022	$39.31	$12.47	$14.50	$0.00	$66.28
	06/01/2023	$40.26	$12.47	$14.50	$0.00	$67.23
	12/01/2023	$41.21	$12.47	$14.50	$0.00	$68.18

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
GENERATORS/LIGHTING PLANTS *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$34.98	$12.47	$14.50	$0.00	$61.95
	12/01/2022	$35.86	$12.47	$14.50	$0.00	$62.83
	06/01/2023	$36.81	$12.47	$14.50	$0.00	$63.78
	12/01/2023	$37.76	$12.47	$14.50	$0.00	$64.73

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
GLAZIER (GLASS PLANK/AIR BARRIER/INTERIOR SYSTEMS) *GLAZIERS LOCAL 1333*	06/01/2020	$39.18	$10.80	$10.45	$0.00	$60.43

Apprentice - *GLAZIER - Local 1333*

Effective Date - 06/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.59	$10.80	$1.80	$0.00	$32.19
2	56	$22.04	$10.80	$1.80	$0.00	$34.64
3	63	$24.49	$10.80	$2.45	$0.00	$37.74
4	69	$26.94	$10.80	$2.45	$0.00	$40.19
5	75	$29.39	$10.80	$3.15	$0.00	$43.34
6	81	$31.83	$10.80	$3.15	$0.00	$45.78
7	88	$34.28	$10.80	$10.45	$0.00	$55.53
8	94	$36.73	$10.80	$10.45	$0.00	$57.98

Notes:

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
GRADER/TRENCHING MACHINE/DERRICK *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
HVAC (DUCTWORK) *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28
For apprentice rates see "Apprentice- SHEET METAL WORKER"						
HVAC (ELECTRICAL CONTROLS) *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- ELECTRICIAN"						
HVAC (TESTING AND BALANCING - AIR) *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28
For apprentice rates see "Apprentice- SHEET METAL WORKER"						
HVAC (TESTING AND BALANCING -WATER) *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"						
HVAC MECHANIC *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"						
HYDRAULIC DRILLS (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
INSULATOR (PIPES & TANKS) *HEAT & FROST INSULATORS LOCAL 6 (SPRINGFIELD)*	09/01/2022	$44.05	$13.80	$17.14	$0.00	$74.99

Apprentice - *ASBESTOS INSULATOR (Pipes & Tanks) - Local 6 Springfield*

Effective Date - 09/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$22.03	$13.80	$12.42	$0.00	$48.25
2	60	$26.43	$13.80	$13.36	$0.00	$53.59
3	70	$30.84	$13.80	$14.31	$0.00	$58.95
4	80	$35.24	$13.80	$15.25	$0.00	$64.29

Notes:

Steps are 1 year

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
IRONWORKER/WELDER *IRONWORKERS LOCAL 7 (SPRINGFIELD AREA)*	09/16/2022	$38.06	$8.25	$22.70	$0.00	$69.01
	03/16/2023	$38.91	$8.25	$22.70	$0.00	$69.86
	09/16/2023	$39.81	$8.25	$22.70	$0.00	$70.76
	03/16/2024	$40.66	$8.25	$22.70	$0.00	$71.61

Apprentice - *IRONWORKER - Local 7 Springfield*

Effective Date - 09/16/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$22.84	$8.25	$22.70	$0.00	$53.79
2	70	$26.64	$8.25	$22.70	$0.00	$57.59
3	75	$28.55	$8.25	$22.70	$0.00	$59.50
4	80	$30.45	$8.25	$22.70	$0.00	$61.40
5	85	$32.35	$8.25	$22.70	$0.00	$63.30
6	90	$34.25	$8.25	$22.70	$0.00	$65.20

Notes:

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
JACKHAMMER & PAVING BREAKER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27

Apprentice - *LABORER - Zone 4 Building and Site*

Effective Date - 06/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$17.69	$9.10	$13.62	$0.00	$40.41
2	70	$20.64	$9.10	$13.62	$0.00	$43.36
3	80	$23.58	$9.10	$13.62	$0.00	$46.30
4	90	$26.53	$9.10	$13.62	$0.00	$49.25

Effective Date - 12/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$18.17	$9.10	$13.62	$0.00	$40.89
2	70	$21.20	$9.10	$13.62	$0.00	$43.92
3	80	$24.23	$9.10	$13.62	$0.00	$46.95
4	90	$27.26	$9.10	$13.62	$0.00	$49.98

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.37	$9.10	$14.69	$0.00	$54.16

Apprentice - *LABORER (Heavy and Highway) - Zone 4*

Effective Date - 12/01/2021

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$18.22	$9.10	$14.69	$0.00	$42.01
2	70	$21.26	$9.10	$14.69	$0.00	$45.05
3	80	$24.30	$9.10	$14.69	$0.00	$48.09
4	90	$27.33	$9.10	$14.69	$0.00	$51.12

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER: CARPENTER TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER: CEMENT FINISHER TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: HAZARDOUS WASTE/ASBESTOS REMOVER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.55	$9.10	$13.91	$0.00	$52.56
	12/01/2022	$30.36	$9.10	$13.91	$0.00	$53.37
	06/01/2023	$31.18	$9.10	$13.91	$0.00	$54.19
	12/01/2023	$31.99	$9.10	$13.91	$0.00	$55.00
For apprentice rates see "Apprentice- LABORER"						
LABORER: MASON TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$31.48	$9.10	$13.62	$0.00	$54.20
	12/01/2022	$32.29	$9.10	$13.62	$0.00	$55.01
	06/01/2023	$33.11	$9.10	$13.62	$0.00	$55.83
	12/01/2023	$33.92	$9.10	$13.62	$0.00	$56.64
	06/01/2024	$34.74	$9.10	$13.62	$0.00	$57.46
	12/01/2024	$35.55	$9.10	$13.62	$0.00	$58.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: MASON TENDER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
LABORER: MULTI-TRADE TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: TREE REMOVER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
This classification applies to the removal of standing trees, and the trimming and removal of branches and limbs when related to public works construction or site clearance incidental to construction . For apprentice rates see "Apprentice- LABORER"						
LASER BEAM OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
LASER BEAM OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MARBLE & TILE FINISHERS *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$38.77	$11.49	$19.53	$0.00	$69.79
	02/01/2023	$39.73	$11.49	$19.53	$0.00	$70.75
	08/01/2023	$41.37	$11.49	$19.53	$0.00	$72.39
	02/01/2024	$42.37	$11.49	$19.53	$0.00	$73.39
	08/01/2024	$44.05	$11.49	$19.53	$0.00	$75.07
	02/01/2025	$45.90	$11.49	$19.53	$0.00	$76.92
	08/01/2025	$46.81	$11.49	$19.53	$0.00	$77.83
	02/01/2026	$47.89	$11.49	$19.53	$0.00	$78.91
	08/01/2026	$49.65	$11.49	$19.53	$0.00	$80.67
	02/01/2027	$50.77	$11.49	$19.53	$0.00	$81.79

Apprentice - *MARBLE-TILE FINISHER-Local 3 Marble/Tile (Spr/Pitt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.39	$11.49	$19.53	$0.00	$50.41
2	60	$23.26	$11.49	$19.53	$0.00	$54.28
3	70	$27.14	$11.49	$19.53	$0.00	$58.16
4	80	$31.02	$11.49	$19.53	$0.00	$62.04
5	90	$34.89	$11.49	$19.53	$0.00	$65.91

Notes:

Apprentice to Journeyworker Ratio:1:5

MARBLE MASON/TILE LAYER(SP/PT)SeeBrick
BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE

See "BRICK/STONE/ARTIFICIAL MASONRY(INCL.MASONRY WATERPROOFING)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MECH. SWEEPER OPERATOR (ON CONST. SITES) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MECHANIC/WELDER/BOOM TRUCK *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MILLWRIGHT (Zone 3) *MILLWRIGHTS LOCAL 1121 - Zone 3*	01/03/2022	$38.91	$8.58	$21.57	$0.00	$69.06
	01/02/2023	$40.16	$8.58	$21.57	$0.00	$70.31

Apprentice - *MILLWRIGHT - Local 1121 Zone 3*

Effective Date - 01/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	55	$21.40	$8.58	$5.72	$0.00	$35.70
2	65	$25.29	$8.58	$17.93	$0.00	$51.80
3	75	$29.18	$8.58	$18.98	$0.00	$56.74
4	85	$33.07	$8.58	$20.01	$0.00	$61.66

Effective Date - 01/02/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	55	$22.09	$8.58	$5.72	$0.00	$36.39
2	65	$26.10	$8.58	$17.93	$0.00	$52.61
3	75	$30.12	$8.58	$18.98	$0.00	$57.68
4	85	$34.14	$8.58	$20.01	$0.00	$62.73

Notes: Step 1&2 Appr. indentured after 1/6/2020 receive no pension,
but do receive annuity. (Step 1 $5.72, Step 2 $6.66)
Steps are 2,000 hours

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MORTAR MIXER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
OILER *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$33.90	$12.47	$14.50	$0.00	$60.87
	12/01/2022	$34.78	$12.47	$14.50	$0.00	$61.75
	06/01/2023	$35.73	$12.47	$14.50	$0.00	$62.70
	12/01/2023	$36.68	$12.47	$14.50	$0.00	$63.65
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
OTHER POWER DRIVEN EQUIPMENT - CLASS VI *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$31.92	$12.47	$14.50	$0.00	$58.89
	12/01/2022	$32.80	$12.47	$14.50	$0.00	$59.77
	06/01/2023	$33.75	$12.47	$14.50	$0.00	$60.72
	12/01/2023	$34.70	$12.47	$14.50	$0.00	$61.67
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
PAINTER (BRIDGES/TANKS) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$54.86	$8.65	$23.05	$0.00	$86.56
	01/01/2023	$56.06	$8.65	$23.05	$0.00	$87.76
	07/01/2023	$57.26	$8.65	$23.05	$0.00	$88.96
	01/01/2024	$58.46	$8.65	$23.05	$0.00	$90.16
	07/01/2024	$59.66	$8.65	$23.05	$0.00	$91.36
	01/01/2025	$60.86	$8.65	$23.05	$0.00	$92.56

Apprentice - *PAINTER Local 35 - BRIDGES/TANKS*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$27.43	$8.65	$0.00	$0.00	$36.08
2	55	$30.17	$8.65	$6.27	$0.00	$45.09
3	60	$32.92	$8.65	$6.84	$0.00	$48.41
4	65	$35.66	$8.65	$7.41	$0.00	$51.72
5	70	$38.40	$8.65	$19.63	$0.00	$66.68
6	75	$41.15	$8.65	$20.20	$0.00	$70.00
7	80	$43.89	$8.65	$20.77	$0.00	$73.31
8	90	$49.37	$8.65	$21.91	$0.00	$79.93

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$28.03	$8.65	$0.00	$0.00	$36.68
2	55	$30.83	$8.65	$6.27	$0.00	$45.75
3	60	$33.64	$8.65	$6.84	$0.00	$49.13
4	65	$36.44	$8.65	$7.41	$0.00	$52.50
5	70	$39.24	$8.65	$19.63	$0.00	$67.52
6	75	$42.05	$8.65	$20.20	$0.00	$70.90
7	80	$44.85	$8.65	$20.77	$0.00	$74.27
8	90	$50.45	$8.65	$21.91	$0.00	$81.01

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER (SPRAY OR SANDBLAST, NEW) * * If 30% or more of surfaces to be painted are new construction, NEW paint rate shall be used.*PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$37.83	$8.65	$19.15	$0.00	$65.63
	01/01/2023	$38.93	$8.65	$19.15	$0.00	$66.73
	07/01/2023	$39.98	$8.65	$19.15	$0.00	$67.78
	01/01/2024	$41.08	$8.65	$19.15	$0.00	$68.88
	07/01/2024	$42.13	$8.65	$19.15	$0.00	$69.93
	01/01/2025	$43.23	$8.65	$19.15	$0.00	$71.03

Apprentice - *PAINTER Local 35 Zone 3 - Spray/Sandblast - New*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.92	$8.65	$0.00	$0.00	$27.57
2	55	$20.81	$8.65	$4.13	$0.00	$33.59
3	60	$22.70	$8.65	$4.50	$0.00	$35.85
4	65	$24.59	$8.65	$4.88	$0.00	$38.12
5	70	$26.48	$8.65	$16.90	$0.00	$52.03
6	75	$28.37	$8.65	$17.28	$0.00	$54.30
7	80	$30.26	$8.65	$17.65	$0.00	$56.56
8	90	$34.05	$8.65	$18.40	$0.00	$61.10

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.47	$8.65	$0.00	$0.00	$28.12
2	55	$21.41	$8.65	$4.13	$0.00	$34.19
3	60	$23.36	$8.65	$4.50	$0.00	$36.51
4	65	$25.30	$8.65	$4.88	$0.00	$38.83
5	70	$27.25	$8.65	$16.90	$0.00	$52.80
6	75	$29.20	$8.65	$17.28	$0.00	$55.13
7	80	$31.14	$8.65	$17.65	$0.00	$57.44
8	90	$35.04	$8.65	$18.40	$0.00	$62.09

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER (SPRAY OR SANDBLAST, REPAINT) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$35.15	$8.65	$19.15	$0.00	$62.95
	01/01/2023	$36.25	$8.65	$19.15	$0.00	$64.05
	07/01/2023	$37.30	$8.65	$19.15	$0.00	$65.10
	01/01/2024	$38.40	$8.65	$19.15	$0.00	$66.20
	07/01/2024	$39.45	$8.65	$19.15	$0.00	$67.25
	01/01/2025	$40.55	$8.65	$19.15	$0.00	$68.35

Apprentice - *PAINTER Local 35 Zone 3 - Spray/Sandblast - Repaint*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$17.58	$8.65	$0.00	$0.00	$26.23
2	55	$19.33	$8.65	$4.13	$0.00	$32.11
3	60	$21.09	$8.65	$4.50	$0.00	$34.24
4	65	$22.85	$8.65	$4.88	$0.00	$36.38
5	70	$24.61	$8.65	$16.90	$0.00	$50.16
6	75	$26.36	$8.65	$17.28	$0.00	$52.29
7	80	$28.12	$8.65	$17.65	$0.00	$54.42
8	90	$31.64	$8.65	$1,171.75	$0.00	$1,212.04

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.13	$8.65	$0.00	$0.00	$26.78
2	55	$19.94	$8.65	$4.13	$0.00	$32.72
3	60	$21.75	$8.65	$4.50	$0.00	$34.90
4	65	$23.56	$8.65	$4.88	$0.00	$37.09
5	70	$25.38	$8.65	$16.90	$0.00	$50.93
6	75	$27.19	$8.65	$17.28	$0.00	$53.12
7	80	$29.00	$8.65	$17.65	$0.00	$55.30
8	90	$32.63	$8.65	$18.40	$0.00	$59.68

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER / TAPER (BRUSH, NEW) * * If 30% or more of surfaces to be painted are new construction, NEW paint rate shall be used.*PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$36.43	$8.65	$19.15	$0.00	$64.23
	01/01/2023	$37.53	$8.65	$19.15	$0.00	$65.33
	07/01/2023	$38.58	$8.65	$19.15	$0.00	$66.38
	01/01/2024	$39.68	$8.65	$19.15	$0.00	$67.48
	07/01/2024	$40.73	$8.65	$19.15	$0.00	$68.53
	01/01/2025	$41.83	$8.65	$19.15	$0.00	$69.63

Apprentice - *PAINTER - Local 35 Zone 3 - BRUSH NEW*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.22	$8.65	$0.00	$0.00	$26.87
2	55	$20.04	$8.65	$4.13	$0.00	$32.82
3	60	$21.86	$8.65	$4.50	$0.00	$35.01
4	65	$23.68	$8.65	$4.88	$0.00	$37.21
5	70	$25.50	$8.65	$16.90	$0.00	$51.05
6	75	$27.32	$8.65	$17.28	$0.00	$53.25
7	80	$29.14	$8.65	$17.65	$0.00	$55.44
8	90	$32.79	$8.65	$18.40	$0.00	$59.84

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.77	$8.65	$0.00	$0.00	$27.42
2	55	$20.64	$8.65	$4.13	$0.00	$33.42
3	60	$22.52	$8.65	$4.50	$0.00	$35.67
4	65	$24.39	$8.65	$4.88	$0.00	$37.92
5	70	$26.27	$8.65	$16.90	$0.00	$51.82
6	75	$28.15	$8.65	$17.28	$0.00	$54.08
7	80	$30.02	$8.65	$17.65	$0.00	$56.32
8	90	$33.78	$8.65	$18.40	$0.00	$60.83

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER / TAPER (BRUSH, REPAINT) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$33.75	$8.65	$19.15	$0.00	$61.55
	01/01/2023	$34.85	$8.65	$19.15	$0.00	$62.65
	07/01/2023	$35.90	$8.65	$19.15	$0.00	$63.70
	01/01/2024	$37.00	$8.65	$19.15	$0.00	$64.80
	07/01/2024	$38.05	$8.65	$19.15	$0.00	$65.85
	01/01/2025	$39.15	$8.65	$19.15	$0.00	$66.95

Apprentice - *PAINTER Local 35 Zone 3 - BRUSH REPAINT*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$16.88	$8.65	$0.00	$0.00	$25.53
2	55	$18.56	$8.65	$4.13	$0.00	$31.34
3	60	$20.25	$8.65	$4.50	$0.00	$33.40
4	65	$21.94	$8.65	$4.88	$0.00	$35.47
5	70	$23.63	$8.65	$16.90	$0.00	$49.18
6	75	$25.31	$8.65	$17.28	$0.00	$51.24
7	80	$27.00	$8.65	$17.65	$0.00	$53.30
8	90	$30.38	$8.65	$18.40	$0.00	$57.43

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$17.43	$8.65	$0.00	$0.00	$26.08
2	55	$19.17	$8.65	$4.13	$0.00	$31.95
3	60	$20.91	$8.65	$4.50	$0.00	$34.06
4	65	$22.65	$8.65	$4.88	$0.00	$36.18
5	70	$24.40	$8.65	$16.90	$0.00	$49.95
6	75	$26.14	$8.65	$17.28	$0.00	$52.07
7	80	$27.88	$8.65	$17.65	$0.00	$54.18
8	90	$31.37	$8.65	$18.40	$0.00	$58.42

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER TRAFFIC MARKINGS (HEAVY/HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)* For apprentice rates see "Apprentice- LABORER (Heavy and Highway)	12/01/2021	$30.37	$9.10	$14.69	$0.00	$54.16
PANEL & PICKUP TRUCKS DRIVER *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$35.78	$13.41	$16.01	$0.00	$65.20
PIER AND DOCK CONSTRUCTOR (UNDERPINNING AND DECK) *PILE DRIVER LOCAL 56 (ZONE 3)* For apprentice rates see "Apprentice- PILE DRIVER"	08/01/2020	$43.53	$9.40	$23.12	$0.00	$76.05
PILE DRIVER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$43.53	$9.40	$23.12	$0.00	$76.05

Apprentice - *PILE DRIVER - Local 56 Zone 3*

Effective Date - 08/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	0	$0.00	$0.00	$0.00	$0.00	$0.00

Notes: Apprentice wages shall be no less than the following Steps;
(Same as set in Zone 1)
1$57.06/2$61.96/3$66.87/4$69.32/5$71.78/6$71.78/7$76.68/8$76.68

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PIPELAYER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PIPELAYER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41

For apprentice rates see "Apprentice- LABORER (Heavy and Highway)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PLUMBER & PIPEFITTER *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86

Apprentice - *PLUMBER/PIPEFITTER - Local 104 Western*

Effective Date - 09/17/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$20.57	$9.55	$10.10	$0.00	$40.22
2	50	$22.86	$9.55	$10.10	$0.00	$42.51
3	55	$25.14	$9.55	$10.10	$0.00	$44.79
4	60	$27.43	$9.55	$10.10	$0.00	$47.08
5	65	$29.71	$9.55	$10.10	$0.00	$49.36
6	70	$32.00	$9.55	$10.10	$0.00	$51.65
7	75	$34.28	$9.55	$10.10	$0.00	$53.93
8	80	$36.57	$9.55	$10.10	$0.00	$56.22
9	80	$36.57	$9.55	$17.10	$0.00	$63.22
10	80	$36.57	$9.55	$17.10	$0.00	$63.22

Effective Date - 03/17/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$21.13	$9.55	$10.10	$0.00	$40.78
2	50	$23.48	$9.55	$10.10	$0.00	$43.13
3	55	$25.83	$9.55	$10.10	$0.00	$45.48
4	60	$28.18	$9.55	$10.10	$0.00	$47.83
5	65	$30.52	$9.55	$10.10	$0.00	$50.17
6	70	$32.87	$9.55	$10.10	$0.00	$52.52
7	75	$35.22	$9.55	$10.10	$0.00	$54.87
8	80	$37.57	$9.55	$10.10	$0.00	$57.22
9	80	$37.57	$9.55	$17.10	$0.00	$64.22
10	80	$37.57	$9.55	$17.10	$0.00	$64.22

Notes: **1:1,2:5,3:9,4:12

Apprentice to Journeyworker Ratio:**

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PNEUMATIC CONTROLS (TEMP.) *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86

For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PNEUMATIC DRILL/TOOL OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41

For apprentice rates see "Apprentice- LABORER (Heavy and Highway)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
POWDERMAN & BLASTER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.48	$9.10	$13.62	$0.00	$53.20
	12/01/2022	$31.29	$9.10	$13.62	$0.00	$54.01
	06/01/2023	$32.11	$9.10	$13.62	$0.00	$54.83
	12/01/2023	$32.92	$9.10	$13.62	$0.00	$55.64
	06/01/2024	$33.74	$9.10	$13.62	$0.00	$56.46
	12/01/2024	$34.55	$9.10	$13.62	$0.00	$57.27

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
POWDERMAN & BLASTER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.37	$9.10	$14.69	$0.00	$55.16
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
PUMP OPERATOR (CONCRETE) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
PUMP OPERATOR (DEWATERING, OTHER) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
READY-MIX CONCRETE DRIVER *TEAMSTERS 404 - Construction Service (Northampton)*	05/01/2020	$22.44	$11.07	$6.50	$0.00	$40.01
RIDE-ON MOTORIZED BUGGY OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
ROLLER OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
ROOFER (Coal tar pitch) *ROOFERS LOCAL 248*	07/01/2022	$38.16	$10.35	$17.25	$0.00	$65.76
	07/01/2023	$38.66	$10.35	$18.75	$0.00	$67.76
For apprentice rates see "Apprentice- ROOFER"						
ROOFER (Inc.Roofer Waterproofng &Roofer Dampproofg) *ROOFERS LOCAL 248*	07/01/2022	$37.66	$10.35	$16.75	$0.00	$64.76
	07/01/2023	$39.16	$10.35	$18.25	$0.00	$67.76

Apprentice - *ROOFER - Local 248*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$22.60	$10.35	$0.00	$0.00	$32.95
2	65	$24.48	$10.35	$16.75	$0.00	$51.58
3	70	$26.36	$10.35	$16.75	$0.00	$53.46
4	75	$28.25	$10.35	$16.75	$0.00	$55.35
5	80	$30.13	$10.35	$16.75	$0.00	$57.23
6	85	$32.01	$10.35	$16.75	$0.00	$59.11
7	90	$33.89	$10.35	$16.75	$0.00	$60.99
8	95	$35.78	$10.35	$16.75	$0.00	$62.88

Effective Date - 07/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$23.50	$10.35	$0.00	$0.00	$33.85
2	65	$25.45	$10.35	$18.25	$0.00	$54.05
3	70	$27.41	$10.35	$18.25	$0.00	$56.01
4	75	$29.37	$10.35	$18.25	$0.00	$57.97
5	80	$31.33	$10.35	$18.25	$0.00	$59.93
6	85	$33.29	$10.35	$18.25	$0.00	$61.89
7	90	$35.24	$10.35	$18.25	$0.00	$63.84
8	95	$37.20	$10.35	$18.25	$0.00	$65.80

Notes:

Steps are 750 hrs.Roofer(Tear Off)1:1; Same as above

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ROOFER SLATE / TILE / PRECAST CONCRETE *ROOFERS LOCAL 248*	07/01/2022	$38.16	$10.35	$17.25	$0.00	$65.76
	07/01/2023	$38.66	$10.35	$18.75	$0.00	$67.76
For apprentice rates see "Apprentice- ROOFER"						
SCRAPER *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
SELF-POWERED ROLLERS AND COMPACTORS (TAMPERS) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
SELF-PROPELLED POWER BROOM *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$34.98	$12.47	$14.50	$0.00	$61.95
	12/01/2022	$35.86	$12.47	$14.50	$0.00	$62.83
	06/01/2023	$36.81	$12.47	$14.50	$0.00	$63.78
	12/01/2023	$37.76	$12.47	$14.50	$0.00	$64.73
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
SHEETMETAL WORKER *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28

Apprentice - *SHEET METAL WORKER - Local 63*

Effective Date - 01/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$17.68	$4.79	$4.67	$0.81	$27.95
2	50	$19.65	$5.32	$5.19	$0.90	$31.06
3	55	$21.61	$5.85	$9.33	$1.10	$37.89
4	60	$23.57	$6.38	$9.33	$1.18	$40.46
5	65	$25.54	$6.92	$9.33	$1.25	$43.04
6	70	$27.50	$7.45	$9.33	$1.33	$45.61
7	75	$29.47	$7.98	$9.33	$1.40	$48.18
8	80	$31.43	$8.51	$16.29	$1.69	$57.92
9	85	$33.40	$9.04	$16.29	$1.76	$60.49
10	90	$35.36	$9.58	$16.29	$1.84	$63.07

Notes:

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
SPECIALIZED EARTH MOVING EQUIP < 35 TONS *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.24	$13.41	$16.01	$0.00	$65.66
SPECIALIZED EARTH MOVING EQUIP > 35 TONS *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.53	$13.41	$16.01	$0.00	$65.95
SPRINKLER FITTER *SPRINKLER FITTERS LOCAL 669*	04/01/2021	$43.14	$10.55	$16.41	$0.00	$70.10

Apprentice - *SPRINKLER FITTER - Local 669*

Effective Date - 04/01/2021

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$19.41	$7.75	$0.00	$0.00	$27.16
2	50	$21.57	$7.75	$0.00	$0.00	$29.32
3	55	$23.73	$10.55	$8.15	$0.00	$42.43
4	60	$25.88	$10.55	$8.15	$0.00	$44.58
5	65	$28.04	$10.55	$8.40	$0.00	$46.99
6	70	$30.20	$10.55	$8.40	$0.00	$49.15
7	75	$32.36	$10.55	$8.40	$0.00	$51.31
8	80	$34.51	$10.55	$8.40	$0.00	$53.46
9	85	$36.67	$10.55	$8.40	$0.00	$55.62
10	90	$38.83	$10.55	$8.40	$0.00	$57.78

Notes:

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TELECOMMUNICATION TECHNICIAN *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47

Apprentice - *TELECOMMUNICATION TECHNICIAN - Local 7*

Effective Date - 07/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.56	$7.35	$0.56	$0.00	$26.47
2	45	$20.88	$7.35	$0.63	$0.00	$28.86
3	50	$23.21	$12.25	$7.20	$0.00	$42.66
4	55	$25.53	$12.25	$7.27	$0.00	$45.05
5	65	$30.17	$12.25	$9.14	$0.00	$51.56
6	70	$32.49	$12.25	$10.37	$0.00	$55.11

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.80	$7.35	$0.56	$0.00	$26.71
2	45	$21.15	$7.35	$0.63	$0.00	$29.13
3	50	$23.51	$12.25	$7.20	$0.00	$42.96
4	55	$25.86	$12.25	$7.27	$0.00	$45.38
5	65	$30.56	$12.25	$9.14	$0.00	$51.95
6	70	$32.91	$12.25	$10.37	$0.00	$55.53

Notes:

Steps are 800 hours

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TERRAZZO FINISHERS *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$58.09	$11.49	$22.34	$0.00	$91.92
	02/01/2023	$59.29	$11.49	$22.34	$0.00	$93.12
	08/01/2023	$61.34	$11.49	$22.34	$0.00	$95.17
	02/01/2024	$62.59	$11.49	$22.34	$0.00	$96.42
	08/01/2024	$64.69	$11.49	$22.34	$0.00	$98.52
	02/01/2025	$65.99	$11.49	$22.34	$0.00	$99.82
	08/01/2025	$68.14	$11.49	$22.34	$0.00	$101.97
	02/10/2026	$69.49	$11.49	$22.34	$0.00	$103.32
	08/01/2026	$71.69	$11.49	$22.34	$0.00	$105.52
	02/01/2027	$73.09	$11.49	$22.34	$0.00	$106.92

Apprentice - *TERRAZZO FINISHER-Local 3 Marble/Tile (Spr/Ptt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.05	$11.49	$22.34	$0.00	$62.88
2	60	$34.85	$11.49	$22.34	$0.00	$68.68
3	70	$40.66	$11.49	$22.34	$0.00	$74.49
4	80	$46.47	$11.49	$22.34	$0.00	$80.30
5	90	$52.28	$11.49	$22.34	$0.00	$86.11

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.65	$11.49	$22.34	$0.00	$63.48
2	60	$35.57	$11.49	$22.34	$0.00	$69.40
3	70	$41.50	$11.49	$22.34	$0.00	$75.33
4	80	$47.43	$11.49	$22.34	$0.00	$81.26
5	90	$53.36	$11.49	$22.34	$0.00	$87.19

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TERRAZZO MECHANIC *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$59.17	$11.49	$22.31	$0.00	$92.97
	02/01/2023	$60.37	$11.49	$22.31	$0.00	$94.17
	08/01/2023	$62.42	$11.49	$22.31	$0.00	$96.22
	02/01/2024	$63.67	$11.49	$22.31	$0.00	$97.47
	08/01/2024	$65.77	$11.49	$22.31	$0.00	$99.57
	02/01/2025	$67.07	$11.49	$22.31	$0.00	$100.87
	08/01/2025	$69.22	$11.49	$22.31	$0.00	$103.02
	02/01/2026	$70.57	$11.49	$22.31	$0.00	$104.37
	08/01/2026	$72.77	$11.49	$22.31	$0.00	$106.57
	02/01/2027	$74.17	$11.49	$22.31	$0.00	$107.97

Apprentice - *TERRAZZO MECH - Local 3 Marble/Tile (Spr/Pitt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.59	$11.49	$22.31	$0.00	$63.39
2	60	$35.50	$11.49	$22.31	$0.00	$69.30
3	70	$41.42	$11.49	$22.31	$0.00	$75.22
4	80	$47.34	$11.49	$22.31	$0.00	$81.14
5	90	$53.25	$11.49	$22.31	$0.00	$87.05

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$30.19	$11.49	$22.31	$0.00	$63.99
2	60	$36.22	$11.49	$22.31	$0.00	$70.02
3	70	$42.26	$11.49	$22.31	$0.00	$76.06
4	80	$48.30	$11.49	$22.31	$0.00	$82.10
5	90	$54.33	$11.49	$22.31	$0.00	$88.13

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TEST BORING DRILLER *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$42.58	$9.10	$17.72	$0.00	$69.40
For apprentice rates see "Apprentice- LABORER"						
TEST BORING DRILLER HELPER *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.30	$9.10	$17.72	$0.00	$68.12
For apprentice rates see "Apprentice- LABORER"						
TEST BORING LABORER *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
For apprentice rates see "Apprentice- LABORER"						
TRACTORS *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
TRAILERS FOR EARTH MOVING EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.82	$13.41	$16.01	$0.00	$66.24
TUNNEL WORK - COMPRESSED AIR *LABORERS (COMPRESSED AIR)*	12/01/2021	$53.41	$9.10	$18.17	$0.00	$80.68
For apprentice rates see "Apprentice- LABORER"						
TUNNEL WORK - COMPRESSED AIR (HAZ. WASTE) *LABORERS (COMPRESSED AIR)*	12/01/2021	$55.41	$9.10	$18.17	$0.00	$82.68
For apprentice rates see "Apprentice- LABORER"						
TUNNEL WORK - FREE AIR *LABORERS (FREE AIR TUNNEL)*	12/01/2021	$45.48	$9.10	$18.17	$0.00	$72.75
For apprentice rates see "Apprentice- LABORER"						
TUNNEL WORK - FREE AIR (HAZ. WASTE) *LABORERS (FREE AIR TUNNEL)*	12/01/2021	$47.48	$9.10	$18.17	$0.00	$74.75

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
VAC-HAUL *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.24	$13.41	$16.01	$0.00	$65.66
WAGON DRILL OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
WATER METER INSTALLER *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PLUMBER/PIPEFITTER" or "PLUMBER/GASFITTER"						

Additional Apprentice Information:

Minimum wage rates for apprentices employed on public works projects are listed above as a percentage of the pre-determined hourly wage rate established by the Commissioner under the provisions of the M.G.L. c. 149, ss. 26-27D. Apprentice ratios are established by the Division of Apprenticeship Training pursuant to M.G.L. c. 23, ss. 11E-11L.

All apprentices must be registered with the Division of Apprenticeship Training in accordance with M.G.L. c. 23, ss. 11E-11L.

All steps are six months (1000 hours.)
Ratios are expressed in allowable number of apprentices to journeymen or fraction thereof, unless otherwise specified.

** Multiple ratios are listed in the comment field.
*** APP to JM; 1:1, 2:2, 2:3, 3:4, 4:4, 4:5, 4:6, 5:7, 6:7, 6:8, 6:9, 7:10, 8:10, 8:11, 8:12, 9:13, 10:13, 10:14, etc.
**** APP to JM; 1:1, 1:2, 2:3, 2:4, 3:5, 4:6, 4:7, 5:8, 6:9, 6:10, 7:11, 8:12, 8:13, 9:14, 10:15, 10:16, etc.

Prevailing Wage Rates

As determined by the Director under the provisions of the Massachusetts General Laws, Chapter 149, Sections 26 to 27H

CHARLES D. BAKER
Governor

KARYN E. POLITO
Lt. Governor

ROSALIN ACOSTA
Secretary

MICHAEL FLANAGAN
Director

Awarding Authority: MassDOT Rail and Transit

Contract Number: 120593 **City/Town:** LENOX

Description of Work: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line. Replacement of two railroad bridges, track work at bridge approaches and wetland mitigation

Job Location: Lenox and Lee

Information about Prevailing Wage Schedules for Awarding Authorities and Contractors

- **The wage rates will remain in effect for the duration of the project, except in the case of multi-year public construction projects. For construction projects lasting longer than one year, awarding authorities must request an updated wage schedule no later than two weeks before the anniversary of the date the contract was executed by the awarding authority and the general contractor.** For multi-year CM AT RISK projects, the awarding authority must request an annual update no later than two weeks before the anniversary date, determined as the earlier of: (a) the execution date of the GMP Amendment, or (b) the execution date of the first amendment to permit procurement of construction services. The annual update requirement is not applicable to 27F “rental of equipment” contracts. **The updated wage schedule must be provided to all contractors, including general and sub-contractors, working on the construction project.**
- This wage schedule applies only to the specific project referenced at the top of this page and uniquely identified by the “Wage Request Number” on all pages of this schedule.
- An Awarding Authority must request an updated wage schedule if it has not opened bids or selected a contractor within 90 days of the date of issuance of the wage schedule. For CM AT RISK projects (bid pursuant to G.L. c.149A), the earlier of: (a) the execution date of the GMP Amendment, or (b) the bid for the first construction scope of work must be within 90-days of the wage schedule issuance date.
- The wage schedule shall be incorporated in any advertisement or call for bids for the project as required by M.G.L. c. 149, § 27. The wage schedule shall be made a part of the contract awarded for the project. The wage schedule must be posted in a conspicuous place at the work site for the life of the project in accordance with M.G.L. c. 149 § 27. The wages listed on the wage schedule must be paid to employees performing construction work on the project whether they are employed by the prime contractor, a filed sub-bidder, or a sub-contractor.
- Apprentices working on the project are required to be registered with the Massachusetts Division of Apprentice Standards (DAS). Apprentices must keep their apprentice identification card on their persons during all work hours on the project. An apprentice registered with DAS may be paid the lower apprentice wage rate at the applicable step as provided on the prevailing wage schedule. **Any apprentice not registered with DAS regardless of whether they are registered with another federal, state, local, or private agency must be paid the journeyworker's rate.**
- Every contractor or subcontractor working on the construction project must submit weekly payroll reports and a Statement of Compliance directly to the awarding authority by mail or email and keep them on file for three years. Each weekly payroll report must contain: the employee’s name, address, occupational classification, hours worked, and wages paid. Do not submit weekly payroll reports to DLS. For a sample payroll reporting form go to http://www.mass.gov/dols/pw.
- Contractors with questions about the wage rates or classifications included on the wage schedule have an affirmative obligation to inquire with DLS at (617) 626-6953.
- Contractors must obtain the wage schedules from awarding authorities. Failure of a contractor or subcontractor to pay the prevailing wage rates listed on the wage schedule to all employees who perform construction work on the project is a violation of the law and subjects the contractor or subcontractor to civil and criminal penalties.
- Employees not receiving the prevailing wage rate set forth on the wage schedule may file a complaint with the Fair Labor Division of the office of the Attorney General at (617) 727-3465.

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
Construction						
(2 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$35.95	$13.41	$16.01	$0.00	$65.37
(3 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.02	$13.41	$16.01	$0.00	$65.44
(4 & 5 AXLE) DRIVER - EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.14	$13.41	$16.01	$0.00	$65.56
ADS/SUBMERSIBLE PILOT *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$103.05	$9.40	$23.12	$0.00	$135.57
For apprentice rates see "Apprentice- PILE DRIVER"						
AIR TRACK OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.23	$9.10	$13.62	$0.00	$52.95
	12/01/2022	$31.04	$9.10	$13.62	$0.00	$53.76
	06/01/2023	$31.86	$9.10	$13.62	$0.00	$54.58
	12/01/2023	$32.67	$9.10	$13.62	$0.00	$55.39
	06/01/2024	$33.49	$9.10	$13.62	$0.00	$56.21
	12/01/2024	$34.30	$9.10	$13.62	$0.00	$57.02
For apprentice rates see "Apprentice- LABORER"						
AIR TRACK OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
ASBESTOS WORKER (PIPES & TANKS) *HEAT & FROST INSULATORS LOCAL 6 (SPRINGFIELD)*	12/01/2020	$34.29	$12.80	$8.95	$0.00	$56.04
ASPHALT RAKER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
ASPHALT RAKER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
AUTOMATIC GRADER-EXCAVATOR (RECLAIMER) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BACKHOE/FRONT-END LOADER OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BARCO-TYPE JUMPING TAMPER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
BATCH/CEMENT PLANT - ON SITE *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
BLOCK PAVER, RAMMER / CURB SETTER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.23	$9.10	$13.62	$0.00	$52.95
	12/01/2022	$31.04	$9.10	$13.62	$0.00	$53.76
	06/01/2023	$31.86	$9.10	$13.62	$0.00	$54.58
	12/01/2023	$32.67	$9.10	$13.62	$0.00	$55.39
	06/01/2024	$33.49	$9.10	$13.62	$0.00	$56.21
	12/01/2024	$34.30	$9.10	$13.62	$0.00	$57.02
For apprentice rates see "Apprentice- LABORER"						
BLOCK PAVER, RAMMER / CURB SETTER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
BOILER MAKER *BOILERMAKERS LOCAL 29*	01/01/2020	$46.10	$7.07	$17.98	$0.00	$71.15

Apprentice - *BOILERMAKER - Local 29*

Effective Date - 01/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	65	$29.97	$7.07	$11.69	$0.00	$48.73
2	65	$29.97	$7.07	$11.69	$0.00	$48.73
3	70	$32.27	$7.07	$12.59	$0.00	$51.93
4	75	$34.58	$7.07	$13.49	$0.00	$55.14
5	80	$36.88	$7.07	$14.38	$0.00	$58.33
6	85	$39.19	$7.07	$15.29	$0.00	$61.55
7	90	$41.49	$7.07	$16.18	$0.00	$64.74
8	95	$43.80	$7.07	$17.09	$0.00	$67.96

Notes:

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
BRICK/STONE/ARTIFICIAL MASONRY (INCL. MASONRY WATERPROOFING) *BRICKLAYERS LOCAL 3 (SPRINGFIELD/PITTSFIELD)*	08/01/2022	$47.56	$11.49	$20.37	$0.00	$79.42
	02/01/2023	$48.76	$11.49	$20.37	$0.00	$80.62
	08/01/2023	$50.81	$11.49	$20.37	$0.00	$82.67
	02/01/2024	$52.06	$11.49	$20.37	$0.00	$83.92
	08/01/2024	$53.31	$11.49	$20.37	$0.00	$85.17
	02/01/2025	$54.61	$11.49	$20.37	$0.00	$86.47
	08/01/2025	$56.76	$11.49	$20.37	$0.00	$88.62
	02/01/2026	$58.11	$11.49	$20.37	$0.00	$89.97
	08/01/2026	$60.31	$11.49	$20.37	$0.00	$92.17
	02/01/2027	$61.71	$11.49	$20.37	$0.00	$93.57

Apprentice - *BRICK/PLASTER/CEMENT MASON - Local 3 Springfield/Pittsfield*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$23.78	$11.49	$20.37	$0.00	$55.64
2	60	$28.54	$11.49	$20.37	$0.00	$60.40
3	70	$33.29	$11.49	$20.37	$0.00	$65.15
4	80	$38.05	$11.49	$20.37	$0.00	$69.91
5	90	$42.80	$11.49	$20.37	$0.00	$74.66

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$24.38	$11.49	$20.37	$0.00	$56.24
2	60	$29.26	$11.49	$20.37	$0.00	$61.12
3	70	$34.13	$11.49	$20.37	$0.00	$65.99
4	80	$39.01	$11.49	$20.37	$0.00	$70.87
5	90	$43.88	$11.49	$20.37	$0.00	$75.74

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
BULLDOZER/POWER SHOVEL/TREE SHREDDER /CLAM SHELL *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
CAISSON & UNDERPINNING BOTTOM MAN *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$42.33	$9.10	$17.72	$0.00	$69.15
For apprentice rates see "Apprentice- LABORER"						
CAISSON & UNDERPINNING LABORER *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
For apprentice rates see "Apprentice- LABORER"						
CAISSON & UNDERPINNING TOP MAN *LABORERS - FOUNDATION AND MARINE*	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
For apprentice rates see "Apprentice- LABORER"						
CARBIDE CORE DRILL OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
CARPENTER *CARPENTERS LOCAL 336 - BERKSHIRE COUNTY*	09/01/2022	$39.82	$7.16	$18.15	$0.00	$65.13
	03/01/2023	$40.32	$7.16	$18.15	$0.00	$65.63

Apprentice - *CARPENTER - Local 336 Berkshire*

Effective Date - 09/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.91	$7.16	$1.40	$0.00	$28.47
2	60	$23.89	$7.16	$1.40	$0.00	$32.45
3	70	$27.87	$7.16	$13.95	$0.00	$48.98
4	75	$29.87	$7.16	$13.95	$0.00	$50.98
5	80	$31.86	$7.16	$15.35	$0.00	$54.37
6	80	$31.86	$7.16	$15.35	$0.00	$54.37
7	90	$35.84	$7.16	$16.75	$0.00	$59.75
8	90	$35.84	$7.16	$16.75	$0.00	$59.75

Effective Date - 03/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$20.16	$7.16	$1.40	$0.00	$28.72
2	60	$24.19	$7.16	$1.40	$0.00	$32.75
3	70	$28.22	$7.16	$13.95	$0.00	$49.33
4	75	$30.24	$7.16	$13.95	$0.00	$51.35
5	80	$32.26	$7.16	$15.35	$0.00	$54.77
6	80	$32.26	$7.16	$15.35	$0.00	$54.77
7	90	$36.29	$7.16	$16.75	$0.00	$60.20
8	90	$36.29	$7.16	$16.75	$0.00	$60.20

Notes:

% Indentured After 10/1/17; 45/45/55/55/70/70/80/80
Step 1&2 $26.70/ 3&4 43.29/ 5&6 50.73/ 7&8 $56.17

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CARPENTER WOOD FRAME *CARPENTERS-ZONE 3 (Wood Frame)*	04/01/2022	$23.66	$7.21	$4.80	$0.00	$35.67
	04/01/2023	$24.16	$7.21	$4.80	$0.00	$36.17

All Aspects of New Wood Frame Work

Apprentice - *CARPENTER (Wood Frame) - Zone 3*

Effective Date - 04/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$14.20	$7.21	$0.00	$0.00	$21.41
2	60	$14.20	$7.21	$0.00	$0.00	$21.41
3	65	$15.38	$7.21	$0.00	$0.00	$22.59
4	70	$16.56	$7.21	$0.00	$0.00	$23.77
5	75	$17.75	$7.21	$3.80	$0.00	$28.76
6	80	$18.93	$7.21	$3.80	$0.00	$29.94
7	85	$20.11	$7.21	$3.80	$0.00	$31.12
8	90	$21.29	$7.21	$3.80	$0.00	$32.30

Effective Date - 04/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$14.50	$7.21	$0.00	$0.00	$21.71
2	60	$14.50	$7.21	$0.00	$0.00	$21.71
3	65	$15.70	$7.21	$0.00	$0.00	$22.91
4	70	$16.91	$7.21	$0.00	$0.00	$24.12
5	75	$18.12	$7.21	$3.80	$0.00	$29.13
6	80	$19.33	$7.21	$3.80	$0.00	$30.34
7	85	$20.54	$7.21	$3.80	$0.00	$31.55
8	90	$21.74	$7.21	$3.80	$0.00	$32.75

Notes:

% Indentured After 10/1/17; 45/45/55/55/70/70/80/80
Step 1&2 $17.86/ 3&4 $20.22/ 5&6 $27.57/ 7&8 $29.94

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CEMENT MASONRY/PLASTERING *BRICKLAYERS LOCAL 3 (SPRINGFIELD/PITTSFIELD)*	01/01/2020	$41.94	$12.70	$17.64	$0.62	$72.90

Apprentice - *CEMENT MASONRY/PLASTERING - Springfield/Pittsfield*

Effective Date - 01/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$20.97	$12.70	$15.41	$0.00	$49.08
2	60	$25.16	$12.70	$17.64	$0.62	$56.12
3	65	$27.26	$12.70	$17.64	$0.62	$58.22
4	70	$29.36	$12.70	$17.64	$0.62	$60.32
5	75	$31.46	$12.70	$17.64	$0.62	$62.42
6	80	$33.55	$12.70	$17.64	$0.62	$64.51
7	90	$37.75	$12.70	$17.64	$0.62	$68.71

Notes:

Steps 3,4 are 500 hrs. All other steps are 1,000 hrs.

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
CHAIN SAW OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
COMPRESSOR OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
CRANE OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$42.24	$12.47	$14.50	$0.00	$69.21
	12/01/2022	$43.12	$12.47	$14.50	$0.00	$70.09
	06/01/2023	$44.07	$12.47	$14.50	$0.00	$71.04
	12/01/2023	$45.02	$12.47	$14.50	$0.00	$71.99
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
DELEADER (BRIDGE) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$54.86	$8.65	$23.05	$0.00	$86.56
	01/01/2023	$56.06	$8.65	$23.05	$0.00	$87.76
	07/01/2023	$57.26	$8.65	$23.05	$0.00	$88.96
	01/01/2024	$58.46	$8.65	$23.05	$0.00	$90.16
	07/01/2024	$59.66	$8.65	$23.05	$0.00	$91.36
	01/01/2025	$60.86	$8.65	$23.05	$0.00	$92.56

Apprentice - *PAINTER Local 35 - BRIDGES/TANKS*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$27.43	$8.65	$0.00	$0.00	$36.08
2	55	$30.17	$8.65	$6.27	$0.00	$45.09
3	60	$32.92	$8.65	$6.84	$0.00	$48.41
4	65	$35.66	$8.65	$7.41	$0.00	$51.72
5	70	$38.40	$8.65	$19.63	$0.00	$66.68
6	75	$41.15	$8.65	$20.20	$0.00	$70.00
7	80	$43.89	$8.65	$20.77	$0.00	$73.31
8	90	$49.37	$8.65	$21.91	$0.00	$79.93

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$28.03	$8.65	$0.00	$0.00	$36.68
2	55	$30.83	$8.65	$6.27	$0.00	$45.75
3	60	$33.64	$8.65	$6.84	$0.00	$49.13
4	65	$36.44	$8.65	$7.41	$0.00	$52.50
5	70	$39.24	$8.65	$19.63	$0.00	$67.52
6	75	$42.05	$8.65	$20.20	$0.00	$70.90
7	80	$44.85	$8.65	$20.77	$0.00	$74.27
8	90	$50.45	$8.65	$21.91	$0.00	$81.01

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
DEMO: ADZEMAN *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$42.33	$9.10	$17.57	$0.00	$69.00
	12/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	06/01/2023	$44.33	$9.10	$17.57	$0.00	$71.00
	12/01/2023	$45.58	$9.10	$17.57	$0.00	$72.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: BACKHOE/LOADER/HAMMER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	12/01/2022	$44.33	$9.10	$17.57	$0.00	$71.00
	06/01/2023	$45.33	$9.10	$17.57	$0.00	$72.00
	12/01/2023	$46.58	$9.10	$17.57	$0.00	$73.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: BURNERS *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.08	$9.10	$17.57	$0.00	$69.75
	12/01/2022	$44.08	$9.10	$17.57	$0.00	$70.75
	06/01/2023	$45.08	$9.10	$17.57	$0.00	$71.75
	12/01/2023	$46.33	$9.10	$17.57	$0.00	$73.00
For apprentice rates see "Apprentice- LABORER"						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
DEMO: CONCRETE CUTTER/SAWYER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	12/01/2022	$44.33	$9.10	$17.57	$0.00	$71.00
	06/01/2023	$45.33	$9.10	$17.57	$0.00	$72.00
	12/01/2023	$46.58	$9.10	$17.57	$0.00	$73.25
For apprentice rates see "Apprentice- LABORER"						
DEMO: JACKHAMMER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$43.08	$9.10	$17.57	$0.00	$69.75
	12/01/2022	$44.08	$9.10	$17.57	$0.00	$70.75
	06/01/2023	$45.08	$9.10	$17.57	$0.00	$71.75
	12/01/2023	$46.33	$9.10	$17.57	$0.00	$73.00
For apprentice rates see "Apprentice- LABORER"						
DEMO: WRECKING LABORER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$42.33	$9.10	$17.57	$0.00	$69.00
	12/01/2022	$43.33	$9.10	$17.57	$0.00	$70.00
	06/01/2023	$44.33	$9.10	$17.57	$0.00	$71.00
	12/01/2023	$45.58	$9.10	$17.57	$0.00	$72.25
For apprentice rates see "Apprentice- LABORER"						
DIVER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$68.70	$9.40	$23.12	$0.00	$101.22
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER TENDER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$49.07	$9.40	$23.12	$0.00	$81.59
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER TENDER (EFFLUENT) *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$73.60	$9.40	$23.12	$0.00	$106.12
For apprentice rates see "Apprentice- PILE DRIVER"						
DIVER/SLURRY (EFFLUENT) *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$103.05	$9.40	$23.12	$0.00	$135.57
For apprentice rates see "Apprentice- PILE DRIVER"						
DRAWBRIDGE OPERATOR (Construction) *DRAWBRIDGE - SEIU LOCAL 888*	07/01/2020	$26.77	$6.67	$3.93	$0.16	$37.53
ELECTRICIAN (Including Core Drilling) *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47

Apprentice - *ELECTRICIAN - Local 7*

Effective Date - 07/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.56	$7.35	$0.56	$0.00	$26.47
2	45	$20.88	$7.35	$0.63	$0.00	$28.86
3	50	$23.21	$12.25	$7.20	$0.00	$42.66
4	55	$25.53	$12.25	$7.27	$0.00	$45.05
5	65	$30.17	$12.25	$9.14	$0.00	$51.56
6	70	$32.49	$12.25	$10.37	$0.00	$55.11

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.80	$7.50	$0.56	$0.00	$26.86
2	45	$21.15	$7.50	$0.63	$0.00	$29.28
3	50	$23.51	$12.50	$7.26	$0.00	$43.27
4	55	$25.86	$12.50	$7.33	$0.00	$45.69
5	65	$30.56	$12.50	$9.27	$0.00	$52.33
6	70	$32.91	$12.50	$10.54	$0.00	$55.95

Notes:

Steps 1-2 are 1000 hrs; Steps 3-6 are 1500 hrs.

Apprentice to Journeyworker Ratio:2:3**

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ELEVATOR CONSTRUCTOR *ELEVATOR CONSTRUCTORS LOCAL 41*	01/01/2022	$58.62	$16.03	$20.21	$0.00	$94.86

Apprentice - *ELEVATOR CONSTRUCTOR - Local 41*

Effective Date - 01/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.31	$16.03	$0.00	$0.00	$45.34
2	55	$32.24	$16.03	$20.21	$0.00	$68.48
3	65	$38.10	$16.03	$20.21	$0.00	$74.34
4	70	$41.03	$16.03	$20.21	$0.00	$77.27
5	80	$46.90	$16.03	$20.21	$0.00	$83.14

Notes:

Steps 1-2 are 6 mos.; Steps 3-5 are 1 year

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ELEVATOR CONSTRUCTOR HELPER *ELEVATOR CONSTRUCTORS LOCAL 41*	01/01/2022	$41.03	$16.03	$20.21	$0.00	$77.27

For apprentice rates see "Apprentice - ELEVATOR CONSTRUCTOR"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FENCE & BEAM RAIL ERECTOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
FENCE & GUARD RAIL ERECTOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
FIELD ENG.INST/ROD-BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$18.84	$4.80	$4.10	$0.00	$27.74
FIELD ENG.PARTY CHIEF:BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$21.33	$4.80	$4.10	$0.00	$30.23
FIELD ENG.SURVEY CHIEF-BLDG,SITE,HVY/HWY *OPERATING ENGINEERS LOCAL 98*	06/01/1999	$22.33	$4.80	$4.10	$0.00	$31.23
FIRE ALARM INSTALLER *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- ELECTRICIAN"						
FIRE ALARM REPAIR / MAINTENANCE / COMMISSIONING *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- TELECOMMUNICATIONS TECHNICIAN"						
FIREMAN *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96

Apprentice - *OPERATING ENGINEERS - Local 98 Class 3*

Effective Date - 06/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$22.93	$12.47	$14.50	$0.00	$49.90
2	70	$26.75	$12.47	$14.50	$0.00	$53.72
3	80	$30.57	$12.47	$14.50	$0.00	$57.54
4	90	$34.39	$12.47	$14.50	$0.00	$61.36

Effective Date - 12/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$23.45	$12.47	$14.50	$0.00	$50.42
2	70	$27.36	$12.47	$14.50	$0.00	$54.33
3	80	$31.27	$12.47	$14.50	$0.00	$58.24
4	90	$35.18	$12.47	$14.50	$0.00	$62.15

Notes:

Steps 1-2 are 1000 hrs.; Steps 3-4 are 2000 hrs.

Apprentice to Journeyworker Ratio:1:6

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FLAGGER & SIGNALER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$24.50	$9.10	$14.69	$0.00	$48.29
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
FLOORCOVERER *FLOORCOVERERS LOCAL 2168 ZONE III*	03/01/2022	$39.22	$7.16	$18.15	$0.00	$64.53

Apprentice - *FLOORCOVERER - Local 2168 Zone III*

Effective Date - 03/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.61	$7.16	$1.40	$0.00	$28.17
2	55	$21.57	$7.16	$1.40	$0.00	$30.13
3	60	$23.53	$7.16	$13.95	$0.00	$44.64
4	65	$25.49	$7.16	$13.95	$0.00	$46.60
5	70	$27.45	$7.16	$15.35	$0.00	$49.96
6	75	$29.42	$7.16	$15.35	$0.00	$51.93
7	80	$31.38	$7.16	$16.75	$0.00	$55.29
8	85	$33.34	$7.16	$16.75	$0.00	$57.25

Notes: Steps are 750 hrs.
% After 10/1/17; 45/45/55/55/70/70/80/80 (1500hr Steps)
Step 1&2 $26.21/ 3&4 $31.49/ 5&6 $49.96/ 7&8 $55.29

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
FORK LIFT *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.43	$12.47	$14.50	$0.00	$65.40
	12/01/2022	$39.31	$12.47	$14.50	$0.00	$66.28
	06/01/2023	$40.26	$12.47	$14.50	$0.00	$67.23
	12/01/2023	$41.21	$12.47	$14.50	$0.00	$68.18
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
GENERATORS/LIGHTING PLANTS *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$34.98	$12.47	$14.50	$0.00	$61.95
	12/01/2022	$35.86	$12.47	$14.50	$0.00	$62.83
	06/01/2023	$36.81	$12.47	$14.50	$0.00	$63.78
	12/01/2023	$37.76	$12.47	$14.50	$0.00	$64.73
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
GLAZIER (GLASS PLANK/AIR BARRIER/INTERIOR SYSTEMS) *GLAZIERS LOCAL 1333*	06/01/2020	$39.18	$10.80	$10.45	$0.00	$60.43

Apprentice - *GLAZIER - Local 1333*

Effective Date - 06/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.59	$10.80	$1.80	$0.00	$32.19
2	56	$22.04	$10.80	$1.80	$0.00	$34.64
3	63	$24.49	$10.80	$2.45	$0.00	$37.74
4	69	$26.94	$10.80	$2.45	$0.00	$40.19
5	75	$29.39	$10.80	$3.15	$0.00	$43.34
6	81	$31.83	$10.80	$3.15	$0.00	$45.78
7	88	$34.28	$10.80	$10.45	$0.00	$55.53
8	94	$36.73	$10.80	$10.45	$0.00	$57.98

Notes:

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
GRADER/TRENCHING MACHINE/DERRICK *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
HVAC (DUCTWORK) *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28
For apprentice rates see "Apprentice- SHEET METAL WORKER"						
HVAC (ELECTRICAL CONTROLS) *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47
For apprentice rates see "Apprentice- ELECTRICIAN"						
HVAC (TESTING AND BALANCING - AIR) *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28
For apprentice rates see "Apprentice- SHEET METAL WORKER"						
HVAC (TESTING AND BALANCING -WATER) *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"						
HVAC MECHANIC *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"						
HYDRAULIC DRILLS (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.12	$9.10	$14.69	$0.00	$54.91
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
INSULATOR (PIPES & TANKS) *HEAT & FROST INSULATORS LOCAL 6 (SPRINGFIELD)*	09/01/2022	$44.05	$13.80	$17.14	$0.00	$74.99

Apprentice - *ASBESTOS INSULATOR (Pipes & Tanks) - Local 6 Springfield*
Effective Date - 09/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$22.03	$13.80	$12.42	$0.00	$48.25
2	60	$26.43	$13.80	$13.36	$0.00	$53.59
3	70	$30.84	$13.80	$14.31	$0.00	$58.95
4	80	$35.24	$13.80	$15.25	$0.00	$64.29

Notes:
Steps are 1 year

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
IRONWORKER/WELDER *IRONWORKERS LOCAL 12*	07/01/2019	$31.55	$6.75	$19.66	$0.00	$57.96

Apprentice - *IRONWORKER - Local 12*
Effective Date - 07/01/2019

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$18.93	$6.75	$3.50	$0.00	$29.18
2	70	$22.09	$6.75	$14.64	$0.00	$43.48
3	80	$25.24	$6.75	$16.22	$0.00	$48.21
4	90	$28.40	$6.75	$17.82	$0.00	$52.97

Notes:
Steps are 1 year

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
JACKHAMMER & PAVING BREAKER OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27

Apprentice - *LABORER - Zone 4 Building and Site*

Effective Date - 06/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$17.69	$9.10	$13.62	$0.00	$40.41
2	70	$20.64	$9.10	$13.62	$0.00	$43.36
3	80	$23.58	$9.10	$13.62	$0.00	$46.30
4	90	$26.53	$9.10	$13.62	$0.00	$49.25

Effective Date - 12/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$18.17	$9.10	$13.62	$0.00	$40.89
2	70	$21.20	$9.10	$13.62	$0.00	$43.92
3	80	$24.23	$9.10	$13.62	$0.00	$46.95
4	90	$27.26	$9.10	$13.62	$0.00	$49.98

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.37	$9.10	$14.69	$0.00	$54.16

Apprentice - *LABORER (Heavy and Highway) - Zone 4*

Effective Date - 12/01/2021

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$18.22	$9.10	$14.69	$0.00	$42.01
2	70	$21.26	$9.10	$14.69	$0.00	$45.05
3	80	$24.30	$9.10	$14.69	$0.00	$48.09
4	90	$27.33	$9.10	$14.69	$0.00	$51.12

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER: CARPENTER TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
LABORER: CEMENT FINISHER TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: HAZARDOUS WASTE/ASBESTOS REMOVER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.55	$9.10	$13.91	$0.00	$52.56
	12/01/2022	$30.36	$9.10	$13.91	$0.00	$53.37
	06/01/2023	$31.18	$9.10	$13.91	$0.00	$54.19
	12/01/2023	$31.99	$9.10	$13.91	$0.00	$55.00
For apprentice rates see "Apprentice- LABORER"						
LABORER: MASON TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$31.48	$9.10	$13.62	$0.00	$54.20
	12/01/2022	$32.29	$9.10	$13.62	$0.00	$55.01
	06/01/2023	$33.11	$9.10	$13.62	$0.00	$55.83
	12/01/2023	$33.92	$9.10	$13.62	$0.00	$56.64
	06/01/2024	$34.74	$9.10	$13.62	$0.00	$57.46
	12/01/2024	$35.55	$9.10	$13.62	$0.00	$58.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: MASON TENDER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
LABORER: MULTI-TRADE TENDER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
For apprentice rates see "Apprentice- LABORER"						
LABORER: TREE REMOVER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.48	$9.10	$13.62	$0.00	$52.20
	12/01/2022	$30.29	$9.10	$13.62	$0.00	$53.01
	06/01/2023	$31.11	$9.10	$13.62	$0.00	$53.83
	12/01/2023	$31.92	$9.10	$13.62	$0.00	$54.64
	06/01/2024	$32.74	$9.10	$13.62	$0.00	$55.46
	12/01/2024	$33.55	$9.10	$13.62	$0.00	$56.27
This classification applies to the removal of standing trees, and the trimming and removal of branches and limbs when related to public works construction or site clearance incidental to construction . For apprentice rates see "Apprentice- LABORER"						
LASER BEAM OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
LASER BEAM OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MARBLE & TILE FINISHERS *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$38.77	$11.49	$19.53	$0.00	$69.79
	02/01/2023	$39.73	$11.49	$19.53	$0.00	$70.75
	08/01/2023	$41.37	$11.49	$19.53	$0.00	$72.39
	02/01/2024	$42.37	$11.49	$19.53	$0.00	$73.39
	08/01/2024	$44.05	$11.49	$19.53	$0.00	$75.07
	02/01/2025	$45.90	$11.49	$19.53	$0.00	$76.92
	08/01/2025	$46.81	$11.49	$19.53	$0.00	$77.83
	02/01/2026	$47.89	$11.49	$19.53	$0.00	$78.91
	08/01/2026	$49.65	$11.49	$19.53	$0.00	$80.67
	02/01/2027	$50.77	$11.49	$19.53	$0.00	$81.79

Apprentice - *MARBLE-TILE FINISHER-Local 3 Marble/Tile (Spr/Pitt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.39	$11.49	$19.53	$0.00	$50.41
2	60	$23.26	$11.49	$19.53	$0.00	$54.28
3	70	$27.14	$11.49	$19.53	$0.00	$58.16
4	80	$31.02	$11.49	$19.53	$0.00	$62.04
5	90	$34.89	$11.49	$19.53	$0.00	$65.91

Notes:

Apprentice to Journeyworker Ratio:1:5

MARBLE MASON/TILE LAYER(SP/PT)SeeBrick
BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE

See "BRICK/STONE/ARTIFICIAL MASONRY(INCL.MASONRY WATERPROOFING)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MECH. SWEEPER OPERATOR (ON CONST. SITES) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MECHANIC/WELDER/BOOM TRUCK *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96

For apprentice rates see "Apprentice- OPERATING ENGINEERS"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MILLWRIGHT (Zone 3) *MILLWRIGHTS LOCAL 1121 - Zone 3*	01/03/2022	$38.91	$8.58	$21.57	$0.00	$69.06
	01/02/2023	$40.16	$8.58	$21.57	$0.00	$70.31

Apprentice - *MILLWRIGHT - Local 1121 Zone 3*

Effective Date - 01/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	55	$21.40	$8.58	$5.72	$0.00	$35.70
2	65	$25.29	$8.58	$17.93	$0.00	$51.80
3	75	$29.18	$8.58	$18.98	$0.00	$56.74
4	85	$33.07	$8.58	$20.01	$0.00	$61.66

Effective Date - 01/02/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	55	$22.09	$8.58	$5.72	$0.00	$36.39
2	65	$26.10	$8.58	$17.93	$0.00	$52.61
3	75	$30.12	$8.58	$18.98	$0.00	$57.68
4	85	$34.14	$8.58	$20.01	$0.00	$62.73

Notes: Step 1&2 Appr. indentured after 1/6/2020 receive no pension,
but do receive annuity. (Step 1 $5.72, Step 2 $6.66)
Steps are 2,000 hours

Apprentice to Journeyworker Ratio:1:4

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
MORTAR MIXER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
OILER *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$33.90	$12.47	$14.50	$0.00	$60.87
	12/01/2022	$34.78	$12.47	$14.50	$0.00	$61.75
	06/01/2023	$35.73	$12.47	$14.50	$0.00	$62.70
	12/01/2023	$36.68	$12.47	$14.50	$0.00	$63.65
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
OTHER POWER DRIVEN EQUIPMENT - CLASS VI *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$31.92	$12.47	$14.50	$0.00	$58.89
	12/01/2022	$32.80	$12.47	$14.50	$0.00	$59.77
	06/01/2023	$33.75	$12.47	$14.50	$0.00	$60.72
	12/01/2023	$34.70	$12.47	$14.50	$0.00	$61.67
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
PAINTER (BRIDGES/TANKS) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$54.86	$8.65	$23.05	$0.00	$86.56
	01/01/2023	$56.06	$8.65	$23.05	$0.00	$87.76
	07/01/2023	$57.26	$8.65	$23.05	$0.00	$88.96
	01/01/2024	$58.46	$8.65	$23.05	$0.00	$90.16
	07/01/2024	$59.66	$8.65	$23.05	$0.00	$91.36
	01/01/2025	$60.86	$8.65	$23.05	$0.00	$92.56

Apprentice - *PAINTER Local 35 - BRIDGES/TANKS*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$27.43	$8.65	$0.00	$0.00	$36.08
2	55	$30.17	$8.65	$6.27	$0.00	$45.09
3	60	$32.92	$8.65	$6.84	$0.00	$48.41
4	65	$35.66	$8.65	$7.41	$0.00	$51.72
5	70	$38.40	$8.65	$19.63	$0.00	$66.68
6	75	$41.15	$8.65	$20.20	$0.00	$70.00
7	80	$43.89	$8.65	$20.77	$0.00	$73.31
8	90	$49.37	$8.65	$21.91	$0.00	$79.93

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$28.03	$8.65	$0.00	$0.00	$36.68
2	55	$30.83	$8.65	$6.27	$0.00	$45.75
3	60	$33.64	$8.65	$6.84	$0.00	$49.13
4	65	$36.44	$8.65	$7.41	$0.00	$52.50
5	70	$39.24	$8.65	$19.63	$0.00	$67.52
6	75	$42.05	$8.65	$20.20	$0.00	$70.90
7	80	$44.85	$8.65	$20.77	$0.00	$74.27
8	90	$50.45	$8.65	$21.91	$0.00	$81.01

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER (SPRAY OR SANDBLAST, NEW) * * If 30% or more of surfaces to be painted are new construction, NEW paint rate shall be used.*PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$37.83	$8.65	$19.15	$0.00	$65.63
	01/01/2023	$38.93	$8.65	$19.15	$0.00	$66.73
	07/01/2023	$39.98	$8.65	$19.15	$0.00	$67.78
	01/01/2024	$41.08	$8.65	$19.15	$0.00	$68.88
	07/01/2024	$42.13	$8.65	$19.15	$0.00	$69.93
	01/01/2025	$43.23	$8.65	$19.15	$0.00	$71.03

Apprentice - *PAINTER Local 35 Zone 3 - Spray/Sandblast - New*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.92	$8.65	$0.00	$0.00	$27.57
2	55	$20.81	$8.65	$4.13	$0.00	$33.59
3	60	$22.70	$8.65	$4.50	$0.00	$35.85
4	65	$24.59	$8.65	$4.88	$0.00	$38.12
5	70	$26.48	$8.65	$16.90	$0.00	$52.03
6	75	$28.37	$8.65	$17.28	$0.00	$54.30
7	80	$30.26	$8.65	$17.65	$0.00	$56.56
8	90	$34.05	$8.65	$18.40	$0.00	$61.10

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$19.47	$8.65	$0.00	$0.00	$28.12
2	55	$21.41	$8.65	$4.13	$0.00	$34.19
3	60	$23.36	$8.65	$4.50	$0.00	$36.51
4	65	$25.30	$8.65	$4.88	$0.00	$38.83
5	70	$27.25	$8.65	$16.90	$0.00	$52.80
6	75	$29.20	$8.65	$17.28	$0.00	$55.13
7	80	$31.14	$8.65	$17.65	$0.00	$57.44
8	90	$35.04	$8.65	$18.40	$0.00	$62.09

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER (SPRAY OR SANDBLAST, REPAINT) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$35.15	$8.65	$19.15	$0.00	$62.95
	01/01/2023	$36.25	$8.65	$19.15	$0.00	$64.05
	07/01/2023	$37.30	$8.65	$19.15	$0.00	$65.10
	01/01/2024	$38.40	$8.65	$19.15	$0.00	$66.20
	07/01/2024	$39.45	$8.65	$19.15	$0.00	$67.25
	01/01/2025	$40.55	$8.65	$19.15	$0.00	$68.35

Apprentice - *PAINTER Local 35 Zone 3 - Spray/Sandblast - Repaint*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$17.58	$8.65	$0.00	$0.00	$26.23
2	55	$19.33	$8.65	$4.13	$0.00	$32.11
3	60	$21.09	$8.65	$4.50	$0.00	$34.24
4	65	$22.85	$8.65	$4.88	$0.00	$36.38
5	70	$24.61	$8.65	$16.90	$0.00	$50.16
6	75	$26.36	$8.65	$17.28	$0.00	$52.29
7	80	$28.12	$8.65	$17.65	$0.00	$54.42
8	90	$31.64	$8.65	$1,171.75	$0.00	$1,212.04

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.13	$8.65	$0.00	$0.00	$26.78
2	55	$19.94	$8.65	$4.13	$0.00	$32.72
3	60	$21.75	$8.65	$4.50	$0.00	$34.90
4	65	$23.56	$8.65	$4.88	$0.00	$37.09
5	70	$25.38	$8.65	$16.90	$0.00	$50.93
6	75	$27.19	$8.65	$17.28	$0.00	$53.12
7	80	$29.00	$8.65	$17.65	$0.00	$55.30
8	90	$32.63	$8.65	$18.40	$0.00	$59.68

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER / TAPER (BRUSH, NEW) * * If 30% or more of surfaces to be painted are new construction, NEW paint rate shall be used.*PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$36.43	$8.65	$19.15	$0.00	$64.23
	01/01/2023	$37.53	$8.65	$19.15	$0.00	$65.33
	07/01/2023	$38.58	$8.65	$19.15	$0.00	$66.38
	01/01/2024	$39.68	$8.65	$19.15	$0.00	$67.48
	07/01/2024	$40.73	$8.65	$19.15	$0.00	$68.53
	01/01/2025	$41.83	$8.65	$19.15	$0.00	$69.63

Apprentice - *PAINTER - Local 35 Zone 3 - BRUSH NEW*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.22	$8.65	$0.00	$0.00	$26.87
2	55	$20.04	$8.65	$4.13	$0.00	$32.82
3	60	$21.86	$8.65	$4.50	$0.00	$35.01
4	65	$23.68	$8.65	$4.88	$0.00	$37.21
5	70	$25.50	$8.65	$16.90	$0.00	$51.05
6	75	$27.32	$8.65	$17.28	$0.00	$53.25
7	80	$29.14	$8.65	$17.65	$0.00	$55.44
8	90	$32.79	$8.65	$18.40	$0.00	$59.84

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$18.77	$8.65	$0.00	$0.00	$27.42
2	55	$20.64	$8.65	$4.13	$0.00	$33.42
3	60	$22.52	$8.65	$4.50	$0.00	$35.67
4	65	$24.39	$8.65	$4.88	$0.00	$37.92
5	70	$26.27	$8.65	$16.90	$0.00	$51.82
6	75	$28.15	$8.65	$17.28	$0.00	$54.08
7	80	$30.02	$8.65	$17.65	$0.00	$56.32
8	90	$33.78	$8.65	$18.40	$0.00	$60.83

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER / TAPER (BRUSH, REPAINT) *PAINTERS LOCAL 35 - ZONE 3*	07/01/2022	$33.75	$8.65	$19.15	$0.00	$61.55
	01/01/2023	$34.85	$8.65	$19.15	$0.00	$62.65
	07/01/2023	$35.90	$8.65	$19.15	$0.00	$63.70
	01/01/2024	$37.00	$8.65	$19.15	$0.00	$64.80
	07/01/2024	$38.05	$8.65	$19.15	$0.00	$65.85
	01/01/2025	$39.15	$8.65	$19.15	$0.00	$66.95

Apprentice - *PAINTER Local 35 Zone 3 - BRUSH REPAINT*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$16.88	$8.65	$0.00	$0.00	$25.53
2	55	$18.56	$8.65	$4.13	$0.00	$31.34
3	60	$20.25	$8.65	$4.50	$0.00	$33.40
4	65	$21.94	$8.65	$4.88	$0.00	$35.47
5	70	$23.63	$8.65	$16.90	$0.00	$49.18
6	75	$25.31	$8.65	$17.28	$0.00	$51.24
7	80	$27.00	$8.65	$17.65	$0.00	$53.30
8	90	$30.38	$8.65	$18.40	$0.00	$57.43

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$17.43	$8.65	$0.00	$0.00	$26.08
2	55	$19.17	$8.65	$4.13	$0.00	$31.95
3	60	$20.91	$8.65	$4.50	$0.00	$34.06
4	65	$22.65	$8.65	$4.88	$0.00	$36.18
5	70	$24.40	$8.65	$16.90	$0.00	$49.95
6	75	$26.14	$8.65	$17.28	$0.00	$52.07
7	80	$27.88	$8.65	$17.65	$0.00	$54.18
8	90	$31.37	$8.65	$18.40	$0.00	$58.42

Notes:

Steps are 750 hrs.

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PAINTER TRAFFIC MARKINGS (HEAVY/HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)* For apprentice rates see "Apprentice- LABORER (Heavy and Highway)	12/01/2021	$30.37	$9.10	$14.69	$0.00	$54.16
PANEL & PICKUP TRUCKS DRIVER *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$35.78	$13.41	$16.01	$0.00	$65.20
PIER AND DOCK CONSTRUCTOR (UNDERPINNING AND DECK) *PILE DRIVER LOCAL 56 (ZONE 3)* For apprentice rates see "Apprentice- PILE DRIVER"	08/01/2020	$43.53	$9.40	$23.12	$0.00	$76.05
PILE DRIVER *PILE DRIVER LOCAL 56 (ZONE 3)*	08/01/2020	$43.53	$9.40	$23.12	$0.00	$76.05

Apprentice - *PILE DRIVER - Local 56 Zone 3*

Effective Date - 08/01/2020

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	0	$0.00	$0.00	$0.00	$0.00	$0.00

Notes: Apprentice wages shall be no less than the following Steps;
(Same as set in Zone 1)
1$57.06/2$61.96/3$66.87/4$69.32/5$71.78/6$71.78/7$76.68/8$76.68

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PIPELAYER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52

For apprentice rates see "Apprentice- LABORER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PIPELAYER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41

For apprentice rates see "Apprentice- LABORER (Heavy and Highway)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PLUMBER & PIPEFITTER *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86

Apprentice - *PLUMBER/PIPEFITTER - Local 104 Western*

Effective Date - 09/17/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$20.57	$9.55	$10.10	$0.00	$40.22
2	50	$22.86	$9.55	$10.10	$0.00	$42.51
3	55	$25.14	$9.55	$10.10	$0.00	$44.79
4	60	$27.43	$9.55	$10.10	$0.00	$47.08
5	65	$29.71	$9.55	$10.10	$0.00	$49.36
6	70	$32.00	$9.55	$10.10	$0.00	$51.65
7	75	$34.28	$9.55	$10.10	$0.00	$53.93
8	80	$36.57	$9.55	$10.10	$0.00	$56.22
9	80	$36.57	$9.55	$17.10	$0.00	$63.22
10	80	$36.57	$9.55	$17.10	$0.00	$63.22

Effective Date - 03/17/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$21.13	$9.55	$10.10	$0.00	$40.78
2	50	$23.48	$9.55	$10.10	$0.00	$43.13
3	55	$25.83	$9.55	$10.10	$0.00	$45.48
4	60	$28.18	$9.55	$10.10	$0.00	$47.83
5	65	$30.52	$9.55	$10.10	$0.00	$50.17
6	70	$32.87	$9.55	$10.10	$0.00	$52.52
7	75	$35.22	$9.55	$10.10	$0.00	$54.87
8	80	$37.57	$9.55	$10.10	$0.00	$57.22
9	80	$37.57	$9.55	$17.10	$0.00	$64.22
10	80	$37.57	$9.55	$17.10	$0.00	$64.22

Notes: **1:1,2:5,3:9,4:12

Apprentice to Journeyworker Ratio:**

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PNEUMATIC CONTROLS (TEMP.) *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86

For apprentice rates see "Apprentice- PIPEFITTER" or "PLUMBER/PIPEFITTER"

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
PNEUMATIC DRILL/TOOL OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41

For apprentice rates see "Apprentice- LABORER (Heavy and Highway)

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
POWDERMAN & BLASTER *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$30.48	$9.10	$13.62	$0.00	$53.20
	12/01/2022	$31.29	$9.10	$13.62	$0.00	$54.01
	06/01/2023	$32.11	$9.10	$13.62	$0.00	$54.83
	12/01/2023	$32.92	$9.10	$13.62	$0.00	$55.64
	06/01/2024	$33.74	$9.10	$13.62	$0.00	$56.46
	12/01/2024	$34.55	$9.10	$13.62	$0.00	$57.27

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
POWDERMAN & BLASTER (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$31.37	$9.10	$14.69	$0.00	$55.16
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
PUMP OPERATOR (CONCRETE) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.74	$12.47	$14.50	$0.00	$65.71
	12/01/2022	$39.62	$12.47	$14.50	$0.00	$66.59
	06/01/2023	$40.57	$12.47	$14.50	$0.00	$67.54
	12/01/2023	$41.52	$12.47	$14.50	$0.00	$68.49
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
PUMP OPERATOR (DEWATERING, OTHER) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
READY-MIX CONCRETE DRIVER *TEAMSTERS 404 - Construction Service (Northampton)*	05/01/2020	$22.44	$11.07	$6.50	$0.00	$40.01
RIDE-ON MOTORIZED BUGGY OPERATOR *LABORERS - ZONE 4 (BUILDING & SITE)*	06/01/2022	$29.73	$9.10	$13.62	$0.00	$52.45
	12/01/2022	$30.54	$9.10	$13.62	$0.00	$53.26
	06/01/2023	$31.36	$9.10	$13.62	$0.00	$54.08
	12/01/2023	$32.17	$9.10	$13.62	$0.00	$54.89
	06/01/2024	$32.99	$9.10	$13.62	$0.00	$55.71
	12/01/2024	$33.80	$9.10	$13.62	$0.00	$56.52
For apprentice rates see "Apprentice- LABORER"						
ROLLER OPERATOR *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
ROOFER (Coal tar pitch) *ROOFERS LOCAL 248*	07/01/2022	$38.16	$10.35	$17.25	$0.00	$65.76
	07/01/2023	$38.66	$10.35	$18.75	$0.00	$67.76
For apprentice rates see "Apprentice- ROOFER"						
ROOFER (Inc.Roofer Waterproofng &Roofer Dampproofg) *ROOFERS LOCAL 248*	07/01/2022	$37.66	$10.35	$16.75	$0.00	$64.76
	07/01/2023	$39.16	$10.35	$18.25	$0.00	$67.76

Apprentice - *ROOFER - Local 248*

Effective Date - 07/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$22.60	$10.35	$0.00	$0.00	$32.95
2	65	$24.48	$10.35	$16.75	$0.00	$51.58
3	70	$26.36	$10.35	$16.75	$0.00	$53.46
4	75	$28.25	$10.35	$16.75	$0.00	$55.35
5	80	$30.13	$10.35	$16.75	$0.00	$57.23
6	85	$32.01	$10.35	$16.75	$0.00	$59.11
7	90	$33.89	$10.35	$16.75	$0.00	$60.99
8	95	$35.78	$10.35	$16.75	$0.00	$62.88

Effective Date - 07/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	60	$23.50	$10.35	$0.00	$0.00	$33.85
2	65	$25.45	$10.35	$18.25	$0.00	$54.05
3	70	$27.41	$10.35	$18.25	$0.00	$56.01
4	75	$29.37	$10.35	$18.25	$0.00	$57.97
5	80	$31.33	$10.35	$18.25	$0.00	$59.93
6	85	$33.29	$10.35	$18.25	$0.00	$61.89
7	90	$35.24	$10.35	$18.25	$0.00	$63.84
8	95	$37.20	$10.35	$18.25	$0.00	$65.80

Notes:

Steps are 750 hrs.Roofer(Tear Off)1:1; Same as above

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
ROOFER SLATE / TILE / PRECAST CONCRETE *ROOFERS LOCAL 248*	07/01/2022	$38.16	$10.35	$17.25	$0.00	$65.76
	07/01/2023	$38.66	$10.35	$18.75	$0.00	$67.76
For apprentice rates see "Apprentice- ROOFER"						
SCRAPER *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$38.21	$12.47	$14.50	$0.00	$65.18
	12/01/2022	$39.09	$12.47	$14.50	$0.00	$66.06
	06/01/2023	$40.04	$12.47	$14.50	$0.00	$67.01
	12/01/2023	$40.99	$12.47	$14.50	$0.00	$67.96
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
SELF-POWERED ROLLERS AND COMPACTORS (TAMPERS) *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						
SELF-PROPELLED POWER BROOM *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$34.98	$12.47	$14.50	$0.00	$61.95
	12/01/2022	$35.86	$12.47	$14.50	$0.00	$62.83
	06/01/2023	$36.81	$12.47	$14.50	$0.00	$63.78
	12/01/2023	$37.76	$12.47	$14.50	$0.00	$64.73
For apprentice rates see "Apprentice- OPERATING ENGINEERS"						

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
SHEETMETAL WORKER *SHEETMETAL WORKERS LOCAL 63*	01/01/2022	$39.29	$10.64	$17.33	$2.02	$69.28

Apprentice - *SHEET METAL WORKER - Local 63*
Effective Date - 01/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$17.68	$4.79	$4.67	$0.81	$27.95
2	50	$19.65	$5.32	$5.19	$0.90	$31.06
3	55	$21.61	$5.85	$9.33	$1.10	$37.89
4	60	$23.57	$6.38	$9.33	$1.18	$40.46
5	65	$25.54	$6.92	$9.33	$1.25	$43.04
6	70	$27.50	$7.45	$9.33	$1.33	$45.61
7	75	$29.47	$7.98	$9.33	$1.40	$48.18
8	80	$31.43	$8.51	$16.29	$1.69	$57.92
9	85	$33.40	$9.04	$16.29	$1.76	$60.49
10	90	$35.36	$9.58	$16.29	$1.84	$63.07

Notes:

Apprentice to Journeyworker Ratio:1:3

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
SPECIALIZED EARTH MOVING EQUIP < 35 TONS *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.24	$13.41	$16.01	$0.00	$65.66
SPECIALIZED EARTH MOVING EQUIP > 35 TONS *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.53	$13.41	$16.01	$0.00	$65.95
SPRINKLER FITTER *SPRINKLER FITTERS LOCAL 669*	04/01/2021	$43.14	$10.55	$16.41	$0.00	$70.10

Apprentice - *SPRINKLER FITTER - Local 669*
Effective Date - 04/01/2021

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	45	$19.41	$7.75	$0.00	$0.00	$27.16
2	50	$21.57	$7.75	$0.00	$0.00	$29.32
3	55	$23.73	$10.55	$8.15	$0.00	$42.43
4	60	$25.88	$10.55	$8.15	$0.00	$44.58
5	65	$28.04	$10.55	$8.40	$0.00	$46.99
6	70	$30.20	$10.55	$8.40	$0.00	$49.15
7	75	$32.36	$10.55	$8.40	$0.00	$51.31
8	80	$34.51	$10.55	$8.40	$0.00	$53.46
9	85	$36.67	$10.55	$8.40	$0.00	$55.62
10	90	$38.83	$10.55	$8.40	$0.00	$57.78

Notes:

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TELECOMMUNICATION TECHNICIAN *ELECTRICIANS LOCAL 7*	07/03/2022	$46.41	$12.25	$13.69	$0.00	$72.35
	01/01/2023	$47.01	$12.50	$13.96	$0.00	$73.47

Apprentice - *TELECOMMUNICATION TECHNICIAN - Local 7*

Effective Date - 07/03/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.56	$7.35	$0.56	$0.00	$26.47
2	45	$20.88	$7.35	$0.63	$0.00	$28.86
3	50	$23.21	$12.25	$7.20	$0.00	$42.66
4	55	$25.53	$12.25	$7.27	$0.00	$45.05
5	65	$30.17	$12.25	$9.14	$0.00	$51.56
6	70	$32.49	$12.25	$10.37	$0.00	$55.11

Effective Date - 01/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	40	$18.80	$7.35	$0.56	$0.00	$26.71
2	45	$21.15	$7.35	$0.63	$0.00	$29.13
3	50	$23.51	$12.25	$7.20	$0.00	$42.96
4	55	$25.86	$12.25	$7.27	$0.00	$45.38
5	65	$30.56	$12.25	$9.14	$0.00	$51.95
6	70	$32.91	$12.25	$10.37	$0.00	$55.53

Notes:

Steps are 800 hours

Apprentice to Journeyworker Ratio:1:1

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TERRAZZO FINISHERS *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$58.09	$11.49	$22.34	$0.00	$91.92
	02/01/2023	$59.29	$11.49	$22.34	$0.00	$93.12
	08/01/2023	$61.34	$11.49	$22.34	$0.00	$95.17
	02/01/2024	$62.59	$11.49	$22.34	$0.00	$96.42
	08/01/2024	$64.69	$11.49	$22.34	$0.00	$98.52
	02/01/2025	$65.99	$11.49	$22.34	$0.00	$99.82
	08/01/2025	$68.14	$11.49	$22.34	$0.00	$101.97
	02/10/2026	$69.49	$11.49	$22.34	$0.00	$103.32
	08/01/2026	$71.69	$11.49	$22.34	$0.00	$105.52
	02/01/2027	$73.09	$11.49	$22.34	$0.00	$106.92

Apprentice - *TERRAZZO FINISHER-Local 3 Marble/Tile (Spr/Ptt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.05	$11.49	$22.34	$0.00	$62.88
2	60	$34.85	$11.49	$22.34	$0.00	$68.68
3	70	$40.66	$11.49	$22.34	$0.00	$74.49
4	80	$46.47	$11.49	$22.34	$0.00	$80.30
5	90	$52.28	$11.49	$22.34	$0.00	$86.11

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.65	$11.49	$22.34	$0.00	$63.48
2	60	$35.57	$11.49	$22.34	$0.00	$69.40
3	70	$41.50	$11.49	$22.34	$0.00	$75.33
4	80	$47.43	$11.49	$22.34	$0.00	$81.26
5	90	$53.36	$11.49	$22.34	$0.00	$87.19

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TERRAZZO MECHANIC *BRICKLAYERS LOCAL 3 (SPR/PITT) - MARBLE & TILE*	08/01/2022	$59.17	$11.49	$22.31	$0.00	$92.97
	02/01/2023	$60.37	$11.49	$22.31	$0.00	$94.17
	08/01/2023	$62.42	$11.49	$22.31	$0.00	$96.22
	02/01/2024	$63.67	$11.49	$22.31	$0.00	$97.47
	08/01/2024	$65.77	$11.49	$22.31	$0.00	$99.57
	02/01/2025	$67.07	$11.49	$22.31	$0.00	$100.87
	08/01/2025	$69.22	$11.49	$22.31	$0.00	$103.02
	02/01/2026	$70.57	$11.49	$22.31	$0.00	$104.37
	08/01/2026	$72.77	$11.49	$22.31	$0.00	$106.57
	02/01/2027	$74.17	$11.49	$22.31	$0.00	$107.97

Apprentice - *TERRAZZO MECH - Local 3 Marble/Tile (Spr/Pitt)*

Effective Date - 08/01/2022

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$29.59	$11.49	$22.31	$0.00	$63.39
2	60	$35.50	$11.49	$22.31	$0.00	$69.30
3	70	$41.42	$11.49	$22.31	$0.00	$75.22
4	80	$47.34	$11.49	$22.31	$0.00	$81.14
5	90	$53.25	$11.49	$22.31	$0.00	$87.05

Effective Date - 02/01/2023

Step	percent	Apprentice Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
1	50	$30.19	$11.49	$22.31	$0.00	$63.99
2	60	$36.22	$11.49	$22.31	$0.00	$70.02
3	70	$42.26	$11.49	$22.31	$0.00	$76.06
4	80	$48.30	$11.49	$22.31	$0.00	$82.10
5	90	$54.33	$11.49	$22.31	$0.00	$88.13

Notes:

Apprentice to Journeyworker Ratio:1:5

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
TEST BORING DRILLER *LABORERS - FOUNDATION AND MARINE* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$42.58	$9.10	$17.72	$0.00	$69.40
TEST BORING DRILLER HELPER *LABORERS - FOUNDATION AND MARINE* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$41.30	$9.10	$17.72	$0.00	$68.12
TEST BORING LABORER *LABORERS - FOUNDATION AND MARINE* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$41.18	$9.10	$17.72	$0.00	$68.00
TRACTORS *OPERATING ENGINEERS LOCAL 98*	06/01/2022	$37.60	$12.47	$14.50	$0.00	$64.57
	12/01/2022	$38.48	$12.47	$14.50	$0.00	$65.45
	06/01/2023	$39.43	$12.47	$14.50	$0.00	$66.40
For apprentice rates see "Apprentice- OPERATING ENGINEERS"	12/01/2023	$40.38	$12.47	$14.50	$0.00	$67.35
TRAILERS FOR EARTH MOVING EQUIPMENT *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.82	$13.41	$16.01	$0.00	$66.24
TUNNEL WORK - COMPRESSED AIR *LABORERS (COMPRESSED AIR)* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$53.41	$9.10	$18.17	$0.00	$80.68
TUNNEL WORK - COMPRESSED AIR (HAZ. WASTE) *LABORERS (COMPRESSED AIR)* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$55.41	$9.10	$18.17	$0.00	$82.68
TUNNEL WORK - FREE AIR *LABORERS (FREE AIR TUNNEL)* For apprentice rates see "Apprentice- LABORER"	12/01/2021	$45.48	$9.10	$18.17	$0.00	$72.75
TUNNEL WORK - FREE AIR (HAZ. WASTE) *LABORERS (FREE AIR TUNNEL)*	12/01/2021	$47.48	$9.10	$18.17	$0.00	$74.75

Classification	Effective Date	Base Wage	Health	Pension	Supplemental Unemployment	Total Rate
For apprentice rates see "Apprentice- LABORER"						
VAC-HAUL *TEAMSTERS JOINT COUNCIL NO. 10 ZONE B*	12/01/2021	$36.24	$13.41	$16.01	$0.00	$65.66
WAGON DRILL OPERATOR (HEAVY & HIGHWAY) *LABORERS - ZONE 4 (HEAVY & HIGHWAY)*	12/01/2021	$30.62	$9.10	$14.69	$0.00	$54.41
For apprentice rates see "Apprentice- LABORER (Heavy and Highway)						
WATER METER INSTALLER *PLUMBERS & PIPEFITTERS LOCAL 104 WESTERN DIVISION*	09/17/2022	$45.71	$9.55	$17.10	$0.00	$72.36
	03/17/2023	$46.96	$9.55	$17.10	$0.00	$73.61
	09/17/2023	$47.96	$9.55	$17.10	$0.00	$74.61
	03/17/2024	$49.21	$9.55	$17.10	$0.00	$75.86
For apprentice rates see "Apprentice- PLUMBER/PIPEFITTER" or "PLUMBER/GASFITTER"						

Additional Apprentice Information:

Minimum wage rates for apprentices employed on public works projects are listed above as a percentage of the pre-determined hourly wage rate established by the Commissioner under the provisions of the M.G.L. c. 149, ss. 26-27D. Apprentice ratios are established by the Division of Apprenticeship Training pursuant to M.G.L. c. 23, ss. 11E-11L.

All apprentices must be registered with the Division of Apprenticeship Training in accordance with M.G.L. c. 23, ss. 11E-11L.

All steps are six months (1000 hours.)
Ratios are expressed in allowable number of apprentices to journeymen or fraction thereof, unless otherwise specified.

** Multiple ratios are listed in the comment field.
*** APP to JM; 1:1, 2:2, 2:3, 3:4, 4:4, 4:5, 4:6, 5:7, 6:7, 6:8, 6:9, 7:10, 8:10, 8:11, 8:12, 9:13, 10:13, 10:14, etc.
**** APP to JM; 1:1, 1:2, 2:3, 2:4, 3:5, 4:6, 4:7, 5:8, 6:9, 6:10, 7:11, 8:12, 8:13, 9:14, 10:15, 10:16, etc.

DOCUMENT A00801

SPECIAL PROVISIONS

REPLACEMENT OF BRIDGES ON BERKSHIRE LINE BRIDGE NO 77.04, LEE MA AND BRIDGE NO 79.81, LENOX MA

These Special Provisions include additional information and contractual requirements, as well as amendments to the Standard Specifications and Supplemental Specifications.

LABOR PARTICIPATION GOALS

Labor participation goals for this project shall be 15.3% for minorities and 6.9% for women for each job category. The goals are applicable to both Contractor's and Subcontractor's on-site construction workforce. Refer to document 00820 for details.

PROJECT DESCRIPTION

The Berkshire Line is approximately 36.2 miles long and runs from Ashley Falls, MA north to Pittsfield, MA. It is currently operated at FRA 49 CFR Part 213 Class I (10 mph freight) and Class II (25 mph freight) speeds.

The major work to be completed is the replacement of bridges and associated track work at mileposts 77.04 and 79.81 and work for wetland mitigation in the towns of Lee and Lenox, MA.

Replacement of Berkshire Line Bridge No. 77.04

Berkshire Line Bridge No. 77.04 is a five-span structure carrying the railroad over Codding Brook in the town of Lee, MA. The bridge carries one railroad track and is subjected to freight traffic. The work to be completed in the contract is to demolish the existing bridge and replace with a precast prestressed concrete ballasted deck bridge.

The existing bridge superstructure consists of an open timber deck on two built-up timber stringer chords. The existing substructure consists of four timber bents and two timber abutments. Two center bents are on timber piles. Stone retaining walls retain the fill behind the two center bents. Timber abutments/dump walls bearing on soil run perpendicular to the tracks and retain the approaches. The existing bridge and retaining walls will be demolished except the timber piles will be cut off at one foot below finish grade.

The replacement bridge is a two-span bridge carrying one railroad track and one safety walk on the east side of the bridge. The proposed superstructure consists of ballasted track on precast prestressed deck beams with an externally mounted steel grating safety walk and hand rail. The proposed substructure consists of precast pile caps on steel piles. The orientation of the proposed pier and abutments follow the water flow at a 25 degree skew to the track. The areas in front the abutments and bridge approaches will be regraded and riprap will be installed as scour protection. Wingwalls, consisting of steel piles and precast concrete lagging, are provided on the east side of both bridge approaches.

The proposed track work on Bridge 77.04 includes reconstruction of approximately 130 linear feet of track. Work proposed includes: the removal of existing track within approximately 45 feet of the bridge on both sides; removal and replacement of ballast in the tie replacement areas, installation of ballast mat; installation of new timber ties; and resetting the existing rails after the new ties have been installed. The existing track outside of the reconstruction area will be surfaced and aligned to meet the proposed track. The elevation of the track will be raised on the approaches and the side slopes will be graded at a 2:1 slope.

The bridge will be constructed during short term temporary rail line closures during non-train operation hours. The work will be accessed, staged and performed within the railroad right-of-way.

Replacement of Berkshire Line Bridge No. 79.81

Berkshire Line Bridge at Milepost 79.81 is a three-span structure carrying the railroad over Willow Creek in the town of Lenox, MA. The bridge carries one railroad track and is subjected to freight traffic. The work to be completed in the contract is to demolish the existing bridge and replace with a precast prestressed concrete ballasted deck bridge.

The existing bridge superstructure consists of an open timber deck on two built-up timber stringer chords. The existing substructure consists of four timber bents on timber piles. U-back timber dump walls behind the end bents retain the approaches.

The replacement bridge is a two-span bridge carrying one railroad track and one safety walk on the east side of the bridge. The proposed superstructure consists of ballasted track on precast prestressed deck beams with an externally mounted steel grating safety walk and hand rail. The proposed substructure consists of precast pile caps on steel piles and precast approaches. The orientation of the proposed pier and abutments are perpendicular to the track. U-back permanent steel sheet pile walls placed in front of the abutments will retain the approaches.

The proposed track work related to Bridge 79.81 includes removal and reconstruction of approximately 130 linear feet of track. Work proposed includes: the removal of existing track within approximately 45 feet of the bridge on both sides; removal of ballast in tie replacement areas, installation of ballast mat; installation of new timber ties; and resetting the existing rails after the new ties have been installed. The existing track outside of the replacement area will be surfaced and aligned to meet the proposed track. The elevation of the track will be raised on the approaches and the side slopes will be graded at a 2:1 slope.

The bridge will be constructed during short term temporary rail line closures during non-train operation hours. The work will be accessed, staged and performed within the railroad right-of-way. Work on the approaches will be performed in-the-dry behind the proposed permanent steel sheet pile walls.

Wetland Mitigation for Replacement of Bridge No. 77.04 and Bridge No. 79.81

Wetland Mitigation for the project's wetland impacts is located adjacent to Hop Brook off Meadow Street in Lee, MA. Work includes furnishing material and the construction and

maintenance of the inland wetland as a replication area as shown on the drawings and as required by the specifications.

Requirements for environmental protections are provided in Document 000841 Water Quality Certification by Massachusetts Department of Environmental Protection.

The right-of-way of railroad is owned by the Commonwealth of Massachusetts, Massachusetts Department of Transportation (MassDOT) and is operated by the Housatonic Railroad (HRRC).

SCOPE OF WORK

The project includes, but is not limited to, the following work items:

This project will involve replacement of two railroad bridges and wetland mitigation located in the towns of Lee and Lenox, MA . The bridges are located on the Housatonic Railroad owned by MassDOT and operated by Housatonic Railroad Company (HRRC).

1. Replacement of Berkshire Line Bridge at Milepost 77.04, with associated approach work as described in the previous section. The existing five-span structure carries the Berkshire Line over Codding Brook in the town of Lee, MA. The proposed bridge is a two-span structure approximately 40’ long.

2. Replacement of Berkshire Line Bridge at Milepost 79.81, with associated approach work as described in the previous section. The existing three-span structure carries the Berkshire Line over unnamed waterway in the town of Lenox, MA. The proposed bridge is a two-span structure approximately 36’ long.

3. Wetland Mitigation for the project’s unavoidable wetland impacts is located adjacent to Hop Brook off Meadow Street in Lee, MA. The mitigation site compensation area is approximately 1,150 sq feet.

Two options for steel piles, H-piles and micropiles, are provided on bid documents. The Contarctor shall select only one option to bid.

A full time dedicated Safety Supervisor and a full time dedicated Quality Supervisor are required to be on site during all work under this contract. Safety Supervisor and quality Supervisor shall successfully complete HRRC Roadway Worker Protection and qualification. See Special Provision Items.

Contractor shall also provide temporary protection of work and property during the Contract period. This includes existing mainlines, sidings, yard tracks, culverts, bridges, grade crossings, access paths, utility easments, and private crossings. Railroad equipment within the work area, including existing ties, rails, switches, and OTM inside and outside the reconstruction limits shall also be protected. After the work is properly completed, Contractor shall be responsible for protecting work and for repairing, replacing, and cleaning of damaged work, so that all work is complete at the time of acceptance of the work. Contractor to remove all temporary protection and coverings at the completion of the Work.

Contractor shall provide, maintain, and operate all required types and quantities of equipment required for the Work. A qualified mechanic shall be on site at all times during construction operations. The mechanic shall be equipped with a truck that contains sufficient tools, replacement parts, and fluids for the equipment being used.

The work to be done under this Contract consists of furnishing all required labor, materials, tools, equipment, and services as indicated in accordance with the provisions of the Contract Documents. The HRRC is responsible for providing railroad protective services. These Specifications describe requirements for construction and for the procurement of materials to be used in the subject project.

Contractor is responsible for completing all track work necessary to perform the work. MassDOT and HRRC will furnish certain materials and products as further described in the Special Provision ITEMS.

All work done under this Contract shall be in conformance with the Standard Specifications for Highways and Bridges dated 2022, the Supplemental Specifications dated June 30, 2022, the latest edition of the *AREMA Manual for Railway Engineering*, MassDOT's MW-1, the Plans, and these *Special Provisions.* In case of conflict between the listed reference documents, use the most stringent provisions.

DESIGNER/PROJECT MANAGER

DESIGNER	PROJECT MANAGER
June Wu, P.E.	MassDOT Rail and Transit Division
HDR Inc.	10 Park Plaza, Room 4160
99 High Street, Suite 2300	Boston, MA 02110
Boston, MA 02110	Attn: Scott Conti
Tel No. (617) 357-7718	Tel No. (857) 368-8965
June.wu@hdrinc.com	scott.conti@state.ma.us

SUBSECTION 2.01 – PROPOSAL FORMS AND PLANS

Amend Subsection 2.01.A of the Standard Specifications with the following:

Bidders must be pre-qualified under MBTA Class 3 – Trackage, MBTA Class 4A- Steel Superstructures and Class 4B – Concrete Superstructure to bid on the project. It is acceptable that a Contractor is pre-qualified for MBTA Class 4A- Steel Superstructures and Class 4B – Concrete Superstructure and one of his/her subcontractors, who will perform track work, is pre-qualified for MBTA Class 3 – Trackage.

GO to the MBTA website below to find MBTA Prequalification Procedures.
https://cdn.mbta.com/uploadedfiles/Business_Center/Bidding_and_Solicitations/Design_and_Construction/Prequalification%20Procedures.pdf

All prospective Bidders who intend to bid on this project must provide the required MBTA pre-qualification certificates to Scott Conti at the MassDOT Rail and Transit Division by email at

Scott.Conti@state.ma.us and June Wu at HDR june.wu@hdrinc.com before 5:00 P. M. on the day before the bid opening date.

SUBSECTION 2.04 – PREPARATION OF PROPOSALS
Replacement this Subsection with the following:

A. Electronic proposals for the following project will be received through the internet using COMMBUYS until the date and time stated below. Bid documents will be posted on www.commbuys.com forthwith after the bid submission deadline. No paper copies of bids will be accepted.

All bidders must have or register for a COMMBUYS account in order to bid on this project. If Bidders are not currently registered with COMMBUYS, they need to register with COMMBUYS at least seven-days prior to the scheduled bid opening date.

B. At the designated time of the bid opening the MassDOT will accept, as the official bid, the set of proposal forms generated from the electronic proposal file submitted by the bidder which includes the documents as described in Section G PROPOSAL REQUIREMENTS .

C. MassDOT will not be responsible for any communications or hardware breakdowns, transmission interruptions, delays, or any other problems that interfere with the receipt or withdrawal of proposals as required above either at the Bidder's transmitting location, at MassDOT's receiving location, or anywhere between these locations will not be considered grounds for a bid protest. MassDOT will not be held responsible if the bidder cannot complete and submit a bid due to failure or incomplete delivery of the files submitted via the Internet.

D. CONTRACTOR QUESTIONS AND ADDENDUM ACKNOWLEDGEMENTS
Prospective bidders are required to submit all questions to the Construction Contracts Designer by 1:00 P.M. on the Thursday of the week before the scheduled bid opening date. Any questions received after this time will not be considered for review by the Department.

Contractors should email questions and addendum acknowledgements to the following email address at june.wu@hdrinc.com. Please put the MassDOT project file number in the subject line.

E. PREBID CONFERENCE
A Prebid Conference will be held on project site see Section F.

F. PREBID SITEWALK
A Pre-Bid Meeting/Pre-Bid Site Walk will be held at 10:00 A.M. on January 10, 2023 at the grade crossing at Golden Hill Road in Lee, MA. Prospective bidders shall bring with them all personal protective equipment which must be worn to access the project site.

G. PROPOSAL REQUIREMENTS

1. To be approved for bidding, the following list of required documents must be submitted the day before bid opening:
   - Prequalification Certificates for MBTA Class 3 – Trackage, MBTA Class 4A- Steel

Superstructures and Class 4B – Concrete Superstructure. The Contractors are required to have the prequalification certificates from MBTA in order to bid on the project. It is acceptable that a Contractor is pre-qualified for MBTA Class 4A- Steel Superstructures and Class 4B – Concrete Superstructure and one of his/her subcontractors, who will perform track work, is prequalified for MBTA Class 3 – Trackage. An award will not be made to a Contractor who is not pre-qualified prior to the opening of proposals.

2. The following list of required documents must be completed and submitted for bid proposal submittal:
   - Cover sheet for CONTRACT DOCUMENTS AND SPECIAL PROVISIONS.
   - DOCUMENT B00420 PROPOSAL
   - DOCUMENT B00438 AFFIDAVIT OF NONCOLLUSION
   - A Proposal Guaranty in the amount of five percent (5%) of the value of the bid per SUBSECTION 2.06 PROPOSAL GUARANTY REQUIRED.
   - A list of equipment proposed to be used during the project.
   - Resumes of key project personnel. The key project personnel shall, acted as management roles, have completed minimum two projects for railroad bridge replacements including prestressed precast concrete superstructure and steel pile foundations
   - Number of staff and crews employed by the Bidder who will work on the project.
   - Names of any subcontractors to be used during the project including the name of a contact person and contact information.
   - A list of previous similar construction projects completed by the Bidder. Projects of similar in size or scope of the work required of this specific contract are required. Include five (5) projects for which the prospective bidder has performed or managed work in each category listed below. The submitting contractor is hereby alerted to that fact that Competency and bidders experience is required in all categories of work listed below. Categories of work and experience requirements are described in Subsection 2.04 H - Required Project Experience AND Categories of work.
     - General Rail Construction On or Around Active Rail Lines
     - Track work
     - Bridge Construction including minimum two projects for railroad bridge replacements including prestressed precast concrete superstructure and steel pile foundations.
   - At least two references from previously completed similar project, which is to include the following information:
     a. Name, title and affiliation of the reference
     b. Address of the reference
     c. Phone number and email address of the reference
   - A preliminary schedule that shows a time frame for completion of the work. Include work windows and proposed dates and time of track outages.

H. REQUIRED PROJECT EXPERIENCE AND CATEGORIES OF WORK

The Contractor must demonstrate competency in performing or managing work in each of the following categories of work. In preparing the Contractor's bid proposal the contractor must exhibit, on previously completed projects that the scope of work for the project required the contractor to perform or manage work in each category of Work listed below.

General Rail Construction On or Around Active Rail Lines

Heavy rail line construction projects including the following work: site preparation, excavation backfill, support of excavation, grading, storm drainage, utilities, sewage and water systems, gravel base courses, bituminous and cement pavements, retaining walls, steel reinforced concrete structures, precast concrete structures, steel structures, timber structures, landscaping, access roadways, fencing, signing and incidental site work. This Class of work is intended to only include the contractor's ability to work on or around active facilities without causing disruption. In preparing the Contractor's bid proposal the contractor must exhibit, on previously completed projects that the scope of work for the project required the contractor to perform or manage work on or around active rapid transit, light rail, commuter rail and/or freight tracks without causing disruption to service.

If the submitting contractor has prequalification for "Class 1 – General Transit Construction" classification under the Massachusetts Bay Transportation Authority, please provide evidence as part of the bid proposal. Prequalification is not required but demonstrates competency in the category of work.

Track Work

Projects consisting of the rehabilitation of, or new construction of trackwork for a railroad. Work includes the placement of track support structure, ballast, wood or concrete ties, direct fixation, rail fastening, switches and turnouts, rail welding placement, tamping, CWR installation, alignment and testing.

Bridge Construction

Construction of bridge structures consists of steel pile supported prestressed precast ballasted deck whether single or multiple span, that spans a body of water, depression, highway or railway, and affords passage for railroads, which is greater than 20 feet in length. Contractors bidding on this Class of Work must own or provide evidence of lease agreements for general construction equipment for excavating, grading, lifting and demolition such as loaders, bulldozers, backhoes and cranes.

SUBSECTION 2.06 PROPOSAL GUARANTY REQUIRED.

Replace Subsection 2.06 of the Standard Specifications in its entirety with the following:

A Proposal Guaranty in the amount of five percent (5%) of the value of the bid is required. The bid deposit shall be a bid bond in a form satisfactory to MassDOT furnished by a surety company incorporated pursuant to Chapter 175, Section 105 of the General Laws or authorized

to do business in the Commonwealth under Chapter 175, Section 106 of the General Laws and satisfactory to MassDOT; or cash; or a certified check drawn on a responsible bank or trust company (or a treasurer's or cashier's check issued by such bank or trust company), payable to the Massachusetts Department of Transportation.

SUBSECTION 4.10 – FINAL CLEANING UP

Amend Subsection 4.10 of the Standard Specifications by adding the following:

DISPOSAL OF EXCESS MATERIAL

Surplus materials obtained from any type of excavation, and all existing and other materials not required to be removed and stacked or needed for use on the project, as determined by the Engineer, shall become the property of the Contractor and disposed of subject to the regulations and requirements of local authorities governing the disposal of such materials, at no additional compensation.

REMOVING AND STACKING OF MATERIALS

Contractor is responsible for obtaining their own yard for storage of all existing and other materials required to be removed and stacked. No separate payment will be made for this work, but all costs in connection there with shall be included in the prices bid for various Contract Items.

EMERALD ASH BORER ADVISORY

To the extent possible, all trees and brush shall be disposed on site, typically chipped and spread in place. When trees or brush must be removed, such as in urban, or otherwise populated areas, Contractor shall identify proposed location for disposal, and provide written notification to the Engineer for approval. Disposal shall be in city or town of project, or at minimum, within county, of construction operations.

SUBSECTION 7.01 – LAWS TO BE OBSERVED

Amend Subsection 7.01 of the Standard Specifications by adding the following:

I. Compliance with the National Defense Authorization Act.

On all projects, the "Prohibition on Certain Telecommunications and Video Surveillance Services or Equipment" Regulation (2 CFR 200.216) prohibits the Contractor from using or furnishing the following telecommunications equipment or services:

- Telecommunications equipment produced by Huawei Technologies Company or 1E Corporation (or any subsidiary or affiliate of such entities).
- For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by Hytera Communications Corporation, Hangzhou Hikvision Digital Technology Company, or Dahua Technology Company (or any subsidiary or affiliate of such entities).

- Telecommunications or video surveillance services provided by such entities or using such equipment.
- Telecommunications or video surveillance equipment or services produced or provided by an entity that the Secretary of Defense, in consultation with the Director of the National Intelligence or the Director of the Federal Bureau of Investigation, reasonably believes to be an entity owned or controlled by, or otherwise connected to, the government of a covered foreign country.

This prohibition applies to all products manufactured by the aforementioned companies, including any individual components or parts.

By submitting a bid on a project, the Contractor certifies that all work will be in compliance with the terms of 2 CFR 200.216. The Contractor shall submit a COC indicating compliance with the above provisions for all telecommunications equipment or services included in the Contract.

Payment for the item in which the materials are incorporated may be withheld until these COCs are received. Any cost involved in furnishing the certificate(s) shall be borne by the Contractor.

BIDDERS LIST

Pursuant to the provisions of 49 CFR Part 26.11 all official bidders will be required to report the names, addresses and telephone numbers of all firms that submitted bids or quotes in connection with this Project. Failure to comply with a written request for this information within 15 business days may result in a recommendation to the Prequalification Committee that prequalification status be suspended until the information is received.

The MassDOT will survey all firms that have submitted bids or quotes during the previous year prior to setting the annual goal and shall request that each firm report its age and gross receipts for the year.

SUBSECTION 7.02 – POLLUTION PREVENTION

Amend Subsection 7.02.II of the Standard Specifications by adding the following:

G. Erosion and Sediment Control

The Engineer has the authority to limit the surface areas of erodible earth material exposed by excavation, borrow and fill, or any such operations, and to direct the Contractor to provide immediate, permanent, or temporary control measures to prevent contamination of any adjacent bodies of water or drainage systems. Such measures will involve the installation of compost filter tubes, staked hay bales, sedimentation basins, silt fences or other control devices or methods as necessary to control erosion and sedimentation.

The erosion and sediment control features installed by the Contractor shall be satisfactorily maintained by the Contractor until acceptance of work under this Contract.

In the event of conflict between these Specifications and Laws, Rules, or Regulations of local agencies, the more restrictive requirements shall apply.

If temporary erosion and sediment control measures are required due to the Contractor's negligence or carelessness, the control measures shall be performed by the Contractor at his/her own expense. Construction of temporary erosion and sediment control measures, which are not attributed to the Contractor's negligence, carelessness, or failure to install permanent controls, will be performed as shown on the Plans and/or as ordered by the Engineer.

Repeated failures by the Contractor to control erosion, pollution, and/or siltation, shall be cause for the Engineer to employ outside assistance or to use his/her own forces to provide the necessary corrective measures. The cost of such assistance plus project engineering costs will be charged to the Contractor and appropriate deductions made from the Contractor's monthly progress estimate.

Payment for temporary soil erosion and sedimentation control work will be included under the various items in this Contract.

SUBSECTION 7.03 – PERMITS AND LICENSES

Replace Subsection 7.03 of the Standard Specifications in its entirety with the following:

The Contractor shall procure all required permits and licenses, pay all charges, fees and taxes and shall give all notices necessary and incidental to the due and lawful prosecution of the work. The cost thereof shall be included in the prices bid for the various items listed in the Proposal. Copies of all required permits and licenses shall be filed with the Engineer prior to the beginning of work.

For overweight vehicles in excess of 130,000 lbs., the Contractor shall provide a copy of each overweight vehicle permit to the Engineer prior to arrival or delivery of the vehicle to a project site. This requirement is for all Contractors, their subcontractors, equipment suppliers and material suppliers.

The Contractor's attention is directed to the provisions of General Laws, Chapter 90, Section 9 as amended, in which it is provided that earth-moving motor vehicles which exceed certain dimensions or weight limits as specified in said Act, and which are used exclusively for building, repair and maintenance of highways, may be operated without registration for a distance not exceeding 300 yd on any way adjacent to any highway or toll road being constructed, relocated or improved provided a permit, authorizing such use, to be issued by the Commissioner of Public Works or by the Board or officer having charge of such way, has been procured by the Contractor.

SUBSECTION 7.05 INSURANCE REQUIREMENTS
B. Public Liability Insurance

Amend Subsection 7.05.b.3 of the Standard Specifications by adding the following:

3. Railroads' Protective Liability and Property Damage Liability Insurance.
Due to the nature of the project, Railroad Protective Insurance will be required for this project with a limit of not less than five Million Dollars ($5,000,000) per occurrence. Such insurance shall also contain an aggregate of not less than ten Million Dollars ($10,000,000) for damages arising out of more than one occurrence.

MassDOT – Rail and Transit Division and the Housatonic Railroad Company shall be named as additional insureds.

SUBSECTION 5.09 INSPECTION OF WORK

Amend Subsection 5.09 of the Standard Specifications by adding the following:

COVID-19 GUIDELINES AND PROCEDURES

Per Subsection 5.09 — Inspection of the Work - the Contractor is required to provide assistance to the Engineer to make a complete and detailed inspection of the work. That assistance includes furnishing equipment to perform the inspection, therefore the Contractor will be required to provide CDC compliant Personal Protective Equipment (PPE) to Department personnel field staff. The CDC compliant PPE shall consist of face masks, gloves and eye protection.

All costs associated with compliance with this provision are considered to be incidental to the Contract cost and therefore the Contractor will not be entitled to any additional compensation.

SUBSECTION 7.09 – PUBLIC SAFETY AND CONVENIENCE

Amend Subsection 7.09 of the Standard Specification by adding the following:

The Contractor shall protect all work areas from unauthorized access by methods acceptable to the Engineer.

The Contractor shall repair any damage to public or private property adjacent to the Project caused by the Contractor's operations and shall leave the property in a condition equal to or better than what it was in prior to commencement of the work.

ACCESS MASSDOT INFORMATION ON WEBSITE

Access MassDOT information related to Construction, Design/Engineering, Contractor/Vendor Information, Approved Materials and Fabricators, Manuals, Publications and Forms at:

Massachusetts Department of Transportation | Mass.gov

PROTECTION OF UNDERGROUND FACILITIES

The Contractor's attention is directed to the necessity of making his own investigation in order to assure that no damage to existing structures, drainage lines, traffic signal conduits, etcetera, will occur.

The Contractor shall notify Massachusetts DIG SAFE and procure a Dig Safe Number for each location prior to disturbing existing ground in any way. Contact the Dig Safe Call Center by 811 or 1-888-344-7233 or online at www.digsafe.com.

WORK SCHEDULE

Use every effort and every means possible to minimize noises caused by construction operations,

which the Engineer may consider as objectionable. Provide working machinery and equipment designed to operate with the least possible noise, and when gearing is used, such gearing shall be of a type designed to reduce noise to a minimum. Equip compressors with silencers on intake lines. Equip gas or oil operated equipment with silencers or mufflers on intake and exhaust lines. Wherever practicable, electricity shall be used for power to reduce noise. Dumping bins, hoppers, and trucks used for disposal of excavated materials shall be lined with wood or other sound deadening material if required. Where required by agencies having jurisdiction, certain noise producing work may have to be performed during specified periods only.

The Contractor shall make all reasonable effort to minimize community disruption that might result from construction, including safety and security problems; the creation of noise, vibration, truck traffic on residential streets, traffic diversions, dust, storage and removal of materials; the choice of location of construction staging, the movement of construction equipment; provision of site cleanup; and hours of operation. Construction activities that may cause community disruption must be agreed upon in consultation with the Engineer prior to the start of construction.

Contractor shall be aware of the codes from the municipalities of Lenox and Lee comply with the codes regulation of construction hours and construction noise levels.

Municipalities through which the Housatonic Railroad operates have varying ordinances which control various activities such as work hours. While Housatonic Railroad believes that the ICC Termination Act exempts railroad activities from local regulation, the Railroad has adopted a “Good Neighbor Policy” and one element of that policy limits, to the extent consistent with efficiency and safety, early morning and late night operations. Accordingly, unless otherwise controlled or allowed by local ordinances, work will not start before 6:30AM and will end before 7:00PM daily.

Noise control is also part of the Railroad’s “Good Neighbor Policy”. Noise from construction operations shall be controlled to the extent possible, including the sounding of horns and warning devices on construction machinery. Nothing set forth in this Section shall relieve Contractors from full compliance with FRA and Commonwealth regulations regarding sounding of horns, whistles and/or bells at crossings and approaching and passing through work zones.

The Contractor shall give notice to the Engineer at least 48 hours in advance of beginning any work affecting the maintenance of traffic and shall not proceed with surfacing operations without specific notice to, and the approval of, the Engineer.

The Contractor shall coordinate with the Engineer and the municipalities of Lenox and Lee to provide access and accommodation for these events. Work on a holiday or on the day before or after a long weekend which involves a holiday requires prior approval by the Engineer. Times will need to be submitted in advance for approval.

TRAIN OPERATIONS

The Housatonic Railroad (HRRC) is an active freight railroad. The railroad shall remain operational throughout the duration of the project. Currently the Housatonic Railroad operates freight service during late afternoon and early evening Monday thru Friday. Anticipated work

windows will be approximately 6am-4pm for Monday thru Friday. There are currently no trains operating on Saturday and daylight trains run on Sunday. Three extended weekend closures from mid-night Friday to noon of the following Monday will be provided for construction at each of Bridge 77.04 and Bridge 79.81. The contractor shall coordinate with HRRC to schedule the weekend closures. The track must be restored for operation by the Contractor at the end of each work window. The train will be advanced to just south of the work area and hold until workers clear each day. However, this schedule is also subject to change due to factors outside HRRC control including customer demands, interchange partners, other construction projects and weather. The contractor shall provide their monthly construction schedule and daily work hours to HRRC two weeks in advance and with weekly updates. HRRC, to the best of its knowledge, will notify the Contractor of any changes in schedule one week in advance.

HRRC is engaged in the business of providing freight rail transportation services in Western Massachusetts. Housatonic Railroad will endeavor to operate its train service to provide track occupancy periods as long as practicable to facilitate efficient construction of the work.

No work will be permitted by the contractor without the Housatonic Railroad EIC (Employee in Charge) being present. Each workday will begin with the required Job Briefing which will be given by the Housatonic Railroad EIC.

Frequent and ongoing communication between the Contractor, the Engineer, and Housatonic Railroad representatives is highly encouraged so as to ensure efficient coordination of work activities and train service.

The Railroad determination of work schedules will take precedence over all other planning and scheduling efforts.
The protection of trains, overall safe operations, and the protection of workmen and railroad personnel are paramount objectives in prosecuting the Work.

SUBSECTION 8.02 SCHEDULE OF OPERATIONS

Replace Subsection 8.02 of the Standard Specifications in its entirety with the following:

An integrated cost and schedule controls program shall be implemented by the Contractor to track and document the progress of the Work from Notice to Proceed (NTP) through the Contractor Field Completion (CFC) Milestone. The Contactor’s schedules will be used by the Engineer to monitor project progress, plan the level-of-effort required by the Department’s work force and consultants and as a critical decision-making tool. Accordingly, the Contractor shall ensure that it complies fully with the requirements specified herein and that its schedules are both accurate and updated as required by the specification throughout the life of the project. Detailed requirements are provided in Division II, Section 722 Construction Scheduling.

SUBSECTION 8.03 PROSECUTION OF WORK

Amend Subsection 8.03 of the Standard Specifications by adding the following:

Prior to the start of any work, the Contractor shall submit the required Scheduling in accordance with Section 722 of these Special Provisions. In addition to Section 722, the Contractor shall comply with the following:

The Contractor shall meet with MassDOT to review their work plan on how they intend to approach the various work items including the number of crews they intend to utilize, and the level of railroad support that they anticipate will be needed.

The Contractor is responsible to restore areas used for site access to their previous condition, which costs shall be considered incidental to the various Contract pay items, unless specific restoration work items are shown on the Plans.

CONTRACTUAL MILESTONES AND DURATIONS:

This Contract contains the following Contractual Milestones that are to be included in the Contractor's Baseline Contract Progress Schedule submission. The Contractor shall identify the completion of the work pertaining to each Contractual Milestone through the inclusion of a Finish Milestone and hammock activities in the accepted baseline Contract Progress Schedule using the stated description.

MS#01 – Contractor Field Completion: The Contractor shall achieve Contractor Completion within **560 calendar days from Notice to Proceed**. Contractor Completion is defined as the completion of all physical contract work including the completion of the punch-list work, and the Contractor has fully demobilized from the field operations.

SUBSECTION 8.06 – LIMITATIONS OF OPERATIONS

Amend SubSection 8.06 of the Standard Specifications by adding the following:

The Contractor shall review the weekday and weekend work windows and confirm with HRRC, for agreement and approval of the work windows. Changes to these work windows will require approval of all railroad entities. Any cost associated with additional outages or time shall be borne by the Contractor. The Contractor shall comply with the limits of work windows and shall clear the tracks and return the site to The Railroad before the specified work windows expire. The site and the track shall conform to FRA standards for safe operation of trains at the end of the work windows. The HRRC Chief Engineer, or representative thereof, shall be the sole judge of the condition of the site and tracks.

The Contractor must clearly identify all aspects of this work in the preparation of the Construction Schedule and throughout the contract duration.
The Contractor is reminded that, in bidding this work, the Contractor is obligated to meet the Contract Milestones and Durations (Time) and is obligated to plan the successful completion of Work, prior to submitting the bid.

In submitting a bid price for this contract, the Contractor acknowledges that a detailed plan, has been developed to meet the Contract Time for all aspects of the Contact; including shift work; extended work hour requirements/restrictions; as well as the planning of all subcontractor and supplier operations.

TRAFFIC CONTROL

Contractor to coordinate all requests for traffic control with MassDOT contact.

For any work that may impact traffic, the Contractor shall be responsible for the scheduling and coordination of the work with the HRRC, municipality, any affected abutters, and MassDOT. All traffic management arrangements shall be the responsibility of the Contractor including all advance notification that may be required and all signage, traffic barricades and police details that may be necessary. Streets and driveways adjacent to the work area shall remain open at all times.

The Contractor may be required to access project locations through adjacent properties. The Contractor shall coordinate with the property owners and provide a minimum advanced notice of 2 weeks prior to the start of work at these locations.

NOTICE TO OWNERS OF UTILITIES

The Contractor shall give written notice to all public service corporations or officials, owning or having charge of public or privately owned utilities, of his intention to commence operations affecting such utilities one week in advance of the commencement of such operations. The Contractor shall, at the same time, file a copy of such notice with the Engineer.

Before commencing work on service connections, the Contractor shall contact the serving utility to ensure that proper construction procedures are followed.
A list of public and private utilities can be found on the MassDOT website at: https://hwy.massdot.state.ma.us/webapps/utilities/select.asp.

The utility contact list is for guidance only and is not guaranteed to be complete or up to date.

NATIONAL GRID EMERGENCY TELEPHONE NUMBERS

GAS:
Emergency: 1-800-233-5325
New Service: 1- 877-696-4743
Customer Support: 1-800-732-3400

EVERSOURCE EMERGENCY TELEPHONE NUMBERS

ELECTRIC:
Outage/ Emergency: 800-592-2000 or 844-726-7562
New Service: 1-888-633-3797 (1-888-need pwr)
Customer Support: 1-800-340-9822

SUBSECTION 7.09 – PUBLIC SAFETY AND CONVENIENCE

Amend Subsection 7.09 of the Standard Specifications by adding the following at the end of the 18th paragraph:

The Engineer may authorize work to continue during these specified time periods if it is determined by the Engineer that the work will not negatively impact the traveling public.

Below are the holiday work restrictions for the calendar years.

New Years Day (Federal Holiday)
Sunday, January 1, 2023

Martin Luther King's Birthday (Federal Holiday)
Monday, January 16, 2023

President's Day (Federal Holiday)
Monday, February 20, 2023

Patriot's Day (State Holiday)
Monday, April 17, 2023

Memorial Day (Federal Holiday)
Monday, May 29, 2023

Juneteenth (Federal Holiday)
Monday, June 19, 2023

Independence Day (Federal Holiday)
Tuesday, July 4, 2023

Labor Day (Federal Holiday)
Monday, September 4, 2023

Columbus Day (Federal Holiday)
Monday, October 9, 2023

Veterans' Day (Federal Holiday)
Friday, November 10, 2023

Thanksgiving Day (Federal Holiday)
Thursday, November 23, 2023

Christmas Day (Federal Holiday)
Monday, December 25, 2023

NORTHERN LONG-EARED BAT PROTECTION

The U.S. Fish and Wildlife Service has listed the northern long-eared bat as threatened under the Endangered Species Act (ESA) and the following requirements exist to protect the bat and its habitat. This project has been reviewed by MassDOT Highway Division's Environmental Services Section, and has been determined to have "No Effect" to the northern long-eared bat. No time of year restrictions are required for the project at this time. If additional cutting is

proposed by the Contractor that is outside the scope of this contract, additional review is required by the MassDOT Highway Division's Environmental Services Section, and time of year restrictions may apply to such tree cutting.

RAILWAY WORKER PROTECTION

Housatonic Railroad strictly adheres to the practice of operating a safe railroad and mandates that all Contractors and their Subcontractors, their Officers, employees, agents and all personnel employed or engaged by them in the performance of the Work or activity while on or adjacent to Railroad property operate and perform all activities in a safe manner and in strict accordance with Housatonic Railroad On-Track Safety Manual and applicable Provisions of 49 CFR Part 214 Railroad Workplace Safety, as promulgated by the Federal Railroad Administration (FRA), in particular:

Subpart B-Bridge Worker Safety Standards
Subpart C-Roadway Worker Protection
Subpart D-Track Roadway Maintenance machines and Hi-Rail Vehicles

All employees, agents and any personnel employed by and or engaged by the Contractor or his Subcontractors shall attend Roadway Worker Protection training conducted by the Railroad, prior to entry upon Railroad property. RWP training provided online by the HRRC shall be completed prior to initiation of work activities and at other times to accommodate the project schedules. The training will be conducted in English. If the Contractor has employees who may not be able to adequately understand the content of the training in English, then the Contractor will be responsible to provide the appropriate translation to ensure that their employees are in compliance with FRA requirements.

Personal Protective Equipment (PPE) requirements are specified in the FRA Regulations and the Housatonic Railroad On-Track Safety Manual. The manual is included in the bid documents. Wearing and use of PPE shall be mandatory and strictly enforced. Failure to adhere to the PPE requirements may be grounds for removal of an individual from Railroad property and prohibition from work. Continual disregard for safety and failure to obey and adhere to safety directives of the Railroad shall be cause for termination of the Contract.

ROADWAY WORKER PROTECTION AND QUALIFICATION

1. Housatonic Roadway Worker Protection ("RWP") training is provided online through the RailPros website. All employees, agents and personnel employed by and or engaged by the Contractor or his Subcontractors working on the Project are required to successfully complete RWP training and to have their training and qualification card on their person while on site. All costs for training are the responsibility of the Contractor.

2. RWP training and qualification is required on an annual basis.

RAILROAD PROVIDED SUPPORT SERVICES

Contractors will be provided the following required Railroad Support Services by Housatonic Railroad (HRRC) personnel:

1. Daily onsite worker safety inspections by HRRC.

2. One full time EIC person and additional personnel as required supplied by HRRC for the duration of the Contractor and/or Subcontractor's presence on site. The EIC person will provide the following services to the Contractor and/or Subcontractor:

    a. Daily Job Briefings at the beginning of each workday and anytime work conditions change.

    b. Coordination of on-track safety protection for the Contractor and/or Subcontractor's personnel and equipment.

    c. Flagging of all train movements through Contractor and/or Subcontractor's work location.

RAILROAD WORK TRAINS

See ITEM 850.42 WORK TRAINS

PROJECT OVERSIGHT

MassDOT representatives will be present on site at times throughout the project for the purpose of representing the Owner's interests with regard to this project and will provide:

1. Oversight and Construction Inspection Services.
2. Act as a liaison between the Railroad and MassDOT.

SUBMITTALS

Prior to beginning any work, the Contractor shall submit to the Engineer for its review and approval proposed work plans, schedules and materials to be used in the Work as required in the specifications and special provisions. Contractor shall not commence any work requiring an approved submittal, including but not limited to schedules, work plans, and materials, without having first received approval by the Engineer.

Contractor shall also be required to submit, as part of their proposal, evidence of Dig Safe notification at project site.

CONDITIONS OF ACCEPTANCE

Materials that do not fully meet the requirements of these Specifications shall be rejected, removed from MassDOT property (if rejected following shipment) and replaced at no additional costs to MassDOT. It is the responsibility of the Contractor to meet the Specifications and in no case is rejection of materials a cause for a change in the contract completion date.

SUBSECTION 8.11 FAILURE TO COMPLETE WORK ON TIME

Remove Table 8.11-1 and amend Subsection 8.11 of the Standard Specifications by adding the following:

If the Contractor fails to comply with the schedule for occupancy which results in HRRC being unable to operate trains or other on-track equipment within the project territory, said Contractor shall pay to the following liquidated damages:

The Liquidated Damages for the Contract is $2,500 per day.

Contractor and MassDOT agree that the liquidated damages established herein are not a penalty but rather constitute an estimate of damages that Owner will sustain by reason of delayed completion. These liquidated damages are intended as compensation for losses that are difficult to estimate. The Contractor and MassDOT agree that this $2,500 per day liquidated damages amount would compensate MassDOT only for construction engineering inspection costs incurred by MassDOT due to the Contractor's failure to complete a portion(s) of the Contract Work by the time(s) stipulated in the schedule proposed by the Contractor and approved by the Housatonic Railroad and MassDOT, as required by the Contract, or the Contractor's failure to complete the whole of the Contract Work by the time stipulated by the Contract. In addition, in the event that the Contractor fails to complete a portion(s) or the whole of the Contract Work by the above-stated times, the Contractor recognizes that MassDOT may incur other expenses which are not covered by the payment of the Liquidated Damages referenced above, including, but not limited to, costs to defend and/or pay third party claims brought against MassDOT for damages.

As a consequence and in addition to the payment of the above referenced Liquidated Damages, the Contractor agrees that it will defend, indemnify and hold MassDOT Harmless from all claims, damages and expenses, other than the construction engineering inspection costs referenced above, which arise, in whole or in part, out of the Contractor's failure to complete a portion(s) or the whole of the Contract Work by the above-stated times.

SUBSECTION 8.14 UTILITY COORDINATION, DOCUMENTATION, AND MONITORING RESPONSIBILITIES

A. GENERAL

In accordance with the provisions of Section 8.00 Prosecution and Progress, utility coordination is a critical aspect to this Contract. This section defines the responsibility of the Contractor and MassDOT, with regard to the initial utility relocation plan and changes that occur as the prosecution of the Work progresses. The Engineer, with assistance from the Contractor shall coordinate with Utility companies that are impacted by the Contractor's operations. To support this effort, the Contractor shall provide routine and accurate schedule updates, provide notification of delays, and provide documentation of the steps taken to resolve any conflicts for the temporary and/or permanent relocations of the impacted utilities. The Contractor shall provide copies to the Engineer of the Contractor communication with the Utility companies, including but not limited to:

- Providing advanced notice, for all utility-related meetings initiated by the Contractor.
- Providing meeting minutes for all utility-related meetings that the Contractor attends.
- Providing all test pit records.
- Request for Early Utility work requirements of this section (see below).

- Notification letters for any proposed changes to Utility start dates and/or sequencing.
- Written notification to the Engineer of all apparent utility delays within seven (7) Calendar Days after a recognized delay to actual work in the field – either caused by a Utility or the Contractor.
- Any communication, initiated by the Contractor, associated with additional Right-of-Way needs in support of utility work.
- Submission of completed Utility Completion Forms.

B. PROJECT UTILITY COORDINATION (PUC) FORM

The utility schedule and sequence information provided in the Project Utility Coordination Form (if applicable) is the best available information at the time of the bid and has been considered in setting the contract duration. The Contractor shall use all of this information in developing the bid price and the Baseline Schedule Submission, inclusive of the individual utility durations sequencing requirements, and any work that has been noted as potentially concurrent utility installations.

C. INITIATION OF UTILITY WORK

The Engineer will issue all initial notice-to-proceed dates to each Utility company based on either the:

1) Contractor's accepted Baseline Schedule
2) An approved Early Utility Request in the form of an Early Utility sub-net schedule (in accordance with the requirements of this Subsection)
3) An approved Proposal Schedule

C.1 - BASELINE SCHEDULE – UTILITY BASIS

The Contractor shall provide a Baseline Schedule submission in accordance with the requirements of Subsection 8.02 and inclusive of all of the information provided in the PUC Form that has been issued in the Contract documents. This is to include the utility durations, sequencing of work, allowable concurrent work, and all applicable considerations that have been depicted on the PUC Form.

C.2 – EARLY UTILITY REQUEST – (aka SUBNET SCHEDULE) PRIOR TO THE BASELINE

All early utility work is defined as any anticipated/required utility relocations that need to occur prior to the Baseline Schedule acceptance. In all cases of proposed early utility relocation, the Contractor shall present all known information at the pre-construction conference in the form of a 'sub-net' schedule showing when each early utility activity needs to be issued a notice-to-proceed. The Contractor shall provide advance notification of this intent to request early utility work in writing at or prior to the Pre-Construction meeting. Prior to officially requesting approval for early utility work, the Contractor shall also coordinate with MassDOT and all utility companies (private, state or municipal) which may be impacted by the Contract. If this request is acceptable to the Utilities and to MassDOT, the Engineer will issue a notice-to-proceed to the affected Utilities, based on these accepted dates.

C.3 – PROPOSAL SCHEDULE - CHANGES TO THE PUC FORM

If the Contractor intends to submit a schedule (in accordance with MassDOT Standard Specifications, Division I, Subsection 8.02) that contains durations or sequencing that vary from

those provided in the Project Utility Coordination (PUC) Form, the Contactor must submit this as an intended change, in the form of a Proposal Schedule and in accordance with MassDOT Standard Specifications, Division I, Subsection 8.02. These proposed changes are subject to the approval of the Engineer and the impacted utilities, in the form of this Proposal Schedule and a proposed revision to the PUC form. The Contractor shall not proceed with any changes of this type without written authorization from the Engineer, that references the approved Proposal Schedule and PUC form changes. The submission of the Baseline Schedule should not include any of these types of proposed utility changes and should not delay the submission of the Baseline Schedule. As a prerequisite to the Proposal Schedule submission, and in advance of the utility notification(s) period, the Contractor shall coordinate the proposed utility changes with the Engineer and the utility companies, to develop a mutually agreed upon schedule, prior to the start of construction.

D. UTILITY DELAYS

The Contractor shall notify the Engineer upon becoming aware that a Utility owner is not advancing the work in accordance with the approved utility schedule. Such notice shall be provided to the Engineer no later than seven (7) calendar days after the occurrence of the event that the Contractor believes to be a utility delay. After such notice, the Engineer and the Contractor shall continue to diligently seek the Utility Owner's cooperation in performing their scope of Work.

In order to demonstrate that a critical path delay has been caused by a third-party Utility, the Contractor must demonstrate, through the requirements of the monthly Progress Schedule submissions and the supporting contract records associated with Subsection 8.02, 8.10 and 8.14, that the delays were beyond the control of the Contractor.

All documentation provided in this section is subject to the review and verification of the Engineer and, if required, the Utility Owner. In accordance with MassDOT Specifications, Division I, Subsection 8.10, a Time Extension will be granted for a delay caused by a Utility, only if the actual duration of the utility work is in excess of that shown on the Project Utility Coordination Form, and only if;

1) proper Notification of Delay was provided to MassDOT in accordance with the time requirements that are specified in this Section
2) the utility delay is a critical path impact to the Baseline Schedule (or most recently approved Progress Schedule)

E. LOCATION OF UTILITIES

The locations of existing utilities are shown on the Contract drawings as an approximation only. The Contractor shall perform a pre-construction utility survey, including any required test pits, to determine the location of all known utilities no later than thirty (30) calendar days before commencing physical site work in the affected area.

F. POST UTILITY SURVEY – NOTIFICATION

Following completion of a utility survey of existing locations, the Contractor will be responsible to notify the Engineer of any known conflicts associated with the actual location of utilities prior to the start of the work. The Engineer and the Contractor will coordinate with any utility whose

assets are to be affected by the Work of this Contract. A partial list of utility contact information is provided in the Project Utility Coordination Form.

G. MEETINGS AND COOPERATION WITH UTILITY OWNERS
The Contractor shall notify the Engineer in advance of any meeting they initiate with a Utility Owner's representative to allow MassDOT to participate in the meeting if needed.

Prior to the Pre-Construction Meeting, the Contractor should meet with all Utility Owners who will be required to perform utility relocations within the first 6 months of the project, to update the affected utilities of the Project Utility Coordination Form and all other applicable Contract requirements that impact the Utilities. The Contractor shall copy the Engineer on any correspondence between the Utility Owner and the Contractor.

H. FORCE ACCOUNT / UTILITY MONITORING REQUIREMENTS

The Engineer will be responsible for recording daily Utility work force reports. The start, suspension, re-start, and completion dates of each of the Utilities, within each phase of the utility relocation work, will be monitored and agreed to by the Engineer and the Contractor as the work progresses.

I. ACCESS AND INSPECTION
The Contractor shall be responsible for allowing Utility owners access to their own utilities to perform the relocations and/or inspections. The Contractor shall schedule their work accordingly so as not to delay or prevent each utility from maintaining their relocation schedule.

PROCEDURE FOR RELEASING AUTOCAD FILES TO THE GENERAL CONTRACTOR

After the bid opening the low bidder may submit the Request for Release of MassDOT AutoCAD Files Form to the Designer. When MassDOT has received both the AutoCAD files from the designer and the Request for Release of MassDOT AutoCAD Files Form from the Contractor, MassDOT will provide files to the Contractor with a reminder disclaimer of use.

SECTION 722
CONSTRUCTION SCHEDULING

DESCRIPTION

722.20 General

The Contractor's approach to prosecution of the Work shall be disclosed to the Department by submission of a Critical Path Method (CPM) schedule and a cost/resource loaded Construction Schedule when required in this Subsection. These requirements are in addition to, and not in limitation of, requirements imposed in other sections.

The requirements for scheduling submissions are established based on the Project Value at the time of the bid and are designated as Type A, B, C or D. The definitions of these Schedule Requirement Types are summarized below. Complete descriptions of all detailed requirements are established elsewhere in this specification.

Type A – for all Site-Specific Contracts with a Project Value over $20 Million

- Schedule Planning Session
- Baseline CPM Schedule
- Monthly Update CPM Schedule
- Short-term Construction Schedule
- Contract Schedule Update Meeting
- Resource-Loading
- Resources Graphic Reporting
- Cash Flow Projections from the CPM
- Cash Flow Charts
- Cost-loaded CPM
- Contractor-furnished CPM software, computer and training

Type B – for all Site-Specific Contracts with a Project Value between $10 Million and $20 Million

- Schedule Planning Session
- Baseline CPM Schedule
- Monthly Update CPM Schedule
- Short-term Construction Schedule
- Contract Schedule Update Meeting
- Cost-loaded CPM
- Resource-Loading
- Monthly Projected Spending Report (PSR)
- Contractor-furnished CPM software, computer and training

Type C – for all Site-Specific Contracts with a Project Value between $3 Million and $10 Million

- Schedule Planning Session
- Baseline CPM Schedule
- Monthly Update CPM Schedule
- Short-term Construction Schedule
- Contract Schedule Update Meeting

SECTION 722 (Continued)

- Monthly Projected Spending Report (PSR)
- Contractor-furnished CPM software, computer and training

Type D - for all contracts with a Project Value less than $3 Million; various locations contracts of any dollar amount; contracts with durations less than one-hundred and eighty (180) Calendar Days; and other contracts as determined by the Engineer.

- Bar chart schedule updated monthly or at the request of the Engineer (See Section 722.62.B - Bar Charts.)
- Monthly Projected Spending Report (PSR) (See Section 722.62.F - Projected Spending Reports.)

MATERIALS, EQUIPMENT, PERSONNEL

722.40 General

A. Software Requirements (Types A, B and C)

The Contractor shall use Primavera P6 computer scheduling software.

In addition to the requirements of Section 740 – Engineer's Field Office and Equipment, the Contractor shall provide to the Department one (1) copy of the scheduling software, one (1) software license and one (1) computer capable of running the scheduling software for the duration of the Contract. This computer and software shall be installed in the Engineer's Field Office within twenty-eight (28) Calendar Days after Notice to Proceed. The computer and software shall be maintained and serviced as recommended by the computer manufacturer and/or as required by the Engineer during the duration of the Contract at no additional cost to the Department. The Contractor shall provide professional training in the basic use of the software for up to eight (8) Department employees. The trainer shall be approved by the Engineer. This training shall be provided within twenty-eight (28) Calendar Days after Notice to Proceed.

B. Scheduler Requirements

For all schedule types, if the Contractor plans to use outside scheduling services, the scheduler shall be approved as a subcontractor by the Engineer.

For Type A, B and C Schedules the name of the Contractor's Project Scheduler together with his/her qualifications shall be submitted to the Department for approval by the Engineer within seven (7) Calendar Days after NTP. The Project Scheduler shall have a minimum of five [5] years of project CPM scheduling experience, three [3] years of which shall be on projects of similar scope and value as the project for which the Project Scheduler is being proposed. References shall be provided from past projects that can attest to the capabilities of the Project Scheduler.

SECTION 722 (Continued)

CONSTRUCTION METHODS

722.60 General

A. Schedule Planning Session
(Types A, B and C)

The Contractor shall conduct a schedule planning session within seven (7) Calendar Days after the Contractor receives the NTP and prior to submission of the Baseline Schedule. This session will be attended by the Department and its consultants. During this session, the Contractor shall present its planned approach to the project including, but not limited to:

1. the Work to be performed by the Contractor and its subcontractors;
2. the planned construction sequence and phasing; planned crew sizes;
3. summary of equipment types, sizes, and numbers to be used for each work activity;
4. all early work related to third party utilities;
5. identification of the most critical submittals and projected submission timelines;
6. estimated durations of major work activities;
7. the anticipated Critical Path of the project and a summary of the activities on that Critical Path;
8. a summary of the most difficult schedule challenges the Contractor is anticipating and how it plans to manage and control those challenges;
9. a summary of the anticipated quarterly cash flow over the life of the project.

This will be an interactive session and the Contractor shall answer all questions that the Department and its consultants may have. The Contractor shall provide a minimum of five (5) copies of a written summary of the information presented and discussed during the session to the Engineer. The Contractor's Baseline Schedule and accompanying Schedule Narrative shall incorporate the information discussed at this Schedule Planning Session.

B. Schedule Reviews by the Department (All Types)

1. Baseline Schedule Reviews
   The Engineer will respond to the Baseline Schedule Submission within thirty (30) Calendar Days of receipt providing comments, questions and/or disposition that either accepts the schedule or requires revision and resubmittal. Baseline Schedules shall be resubmitted within fifteen (15) Calendar Days after receipt of the Engineer's comments.

2. Contract Progress Schedule / Monthly Update Reviews
   The Engineer will respond to each submittal within twenty one (21) Calendar Days. Schedules shall be resubmitted by the Contractor within five (5) Calendar Days after receipt of the Engineer's comments.

   Failure to submit schedules as and when required could result in the withholding of full or partial pay estimate payments by the Engineer.

SECTION 722 (Continued)

722.61 Schedule Content and Preparation Requirements
(Types A, B and C unless otherwise noted)

Each Contract Progress Schedule shall fully conform to these requirements.

A. LOGIC

The schedules shall divide the Work into activities with appropriate logic ties to show:

1. conformance with the requirements of this Section and Division I, Subsection 8.02 - Schedule of Operations
2. the Contractor's overall approach to the planning, scheduling and execution of the Work
3. Conformance with any additional sequences of Work required by the Contract Documents, including, but not limited to, Subsection 8.03 - Prosecution of Work and Subsection 8.06 – Limitations of Operations.

B. ACTIVITIES

The schedules shall clearly define the progression of the Work from NTP to Contractor Field Completion (CFC) by using separate activities for each of the following items:

1. NTP
2. Each component of the Work defined by specific activities
3. Detailed activities to satisfy permit requirements
4. Procurement of fabricated materials and equipment with long lead times, including time for review and approval of submittals required before purchasing
5. The preparation and submission of shop drawings, procedures and other required submittals, with a planned duration that is to be demonstrated to the Engineer as reasonable
6. The review and return of shop drawings, procedures and other required submittals, approved or with comments, the duration of which shall be thirty (30) Calendar Days, unless otherwise specified or as approved by the Engineer
7. Interfaces with adjacent work, utility companies, other public agencies, sensitive abutters, and/or any other third party work affecting the Contract
8. The Critical Path, clearly defined and organized
9. Float shall be clearly identified
10. Access Restraints – restrictions on access to areas of the Work that are defined by the Department in the bid package, in Subsection 8.06 – Limitations of Operations or elsewhere in the Contract
11. Milestones listed in Subsection 8.03 - Prosecution of Work or elsewhere in the Contract Documents
12. Subcontractor approvals at fifteen (15) Calendar Days from submittal to response
13. Full Beneficial Use (FBU) Contract Milestone per the requirements of Subsection 8.03 - Prosecution of Work
14. Contractor’s request for validation of FBU (ready to open to traffic)
15. The Department’s confirmation of completed work to allow for FBU

SECTION 722 (Continued)

16. Substantial Completion Contract Milestone per the requirements of Subsections 7.15 - Claims Against Contractors for Payment of Labor, Materials, and Other Purposes and 8.03 - Prosecution of Work
17. Contractor's request for validation of Substantial Completion
18. Punchlist Completion Period of at least thirty (30) Calendar Days per the requirements of Subsections 5.11 - Final Acceptance, 7.15 - Claims Against Contractors for Payment of Labor, Materials and Other Purposes and 8.03 - Prosecution of Work
19. Contractor confirmation that all punchlist work and documentation has been completed
20. Physical Completion of the Work Contract Milestone per the requirements of Subsections 5.11 - Final Acceptance and 8.03 - Prosecution of Work
21. Documentation Completion per the requirements of Subsections 5.11 - Final Acceptance and 8.03 - Prosecution of Work
22. Contractor Field Completion Contract Milestone per the requirements of Subsections 5.11 - Final Acceptance and 8.03 - Prosecution of Work
23. Utility work to be performed in accordance with the Project Utility Coordination (PUC) Form as provided in Section 8.14 - Utilities Coordination, Documentation and Monitoring Responsibilities
24. Traffic work zone set-up and removal, night work and phasing
25. Early Utility Relocation (by others) that has been identified in the Contract
26. Right-of-Way (ROW) takings that have been identified in the Contract
27. Material Certifications
28. Work Breakdown Structure in accordance with the MassDOT-Highway Division Contractor Construction Schedule Toolkit located on the MassDOT-Highway Division website at: http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/Construction/ConstructionScheduleToolkit.aspx
29. For Type A and B Contracts only: All items to be paid, including all Unit Price and Lump Sum pay items, shall be identified by activity. This shall include all non-construction activities such as engineering work; purchase of permanent materials and equipment, purchase of structural steel stock, equipment procurement, equipment delivery to the site or storage location and the representative amount of overhead/indirect costs that was included in the Contractor's Bid Prices.

C. EARLY AND LATE DATES

Early Dates shall be based on proceeding with the Work or a designated part of the Work exactly on the date when the corresponding Contract Time commences. Late Dates shall be based on completing the Work or a designated part of the Work exactly on the corresponding Contract Time, even if the Contractor anticipates early completion.

SECTION 722 (Continued)

D. DURATIONS

Activity durations shall be in Work Days. Planned Original Durations shall be established with consideration to resources and production rates that correspond to the Contractor's Bid Price. Within all of the Department-required schedules, the Contractor shall plan the Work using durations for all physical construction activities of no less than one (1) Work Day and no greater than fourteen (14) Work Days, unless approved by the Engineer as part of the Baseline Schedule Review.

Should there be an activity with a duration that is determined by the Engineer to be unreasonable, the Contractor will be asked to provide a basis of the duration using bid documents, historic production rates for similar work, or other form of validation that is acceptable to the Engineer. Should the Contractor and the Engineer be unable to agree on reasonable activity durations, the Engineer will, at a minimum, note the disagreement in the Baseline Schedule Review along with a duration the Engineer considers reasonable and the basis for that duration. A schedule that contains a substantial number of activities with durations that are deemed unreasonable by the Engineer will not be accepted.

E. MATERIALS ON HAND (for Types A and B only)

The Contractor shall identify in the Baseline Schedule all items of permanent materials (Materials On Hand) for which the Contractor intends to request payment prior to the incorporation of such items into the Work.

F. ACTIVITY DESCRIPTIONS

The Contractor shall use activity descriptions in all schedules that clearly describe the work to be performed using a combination of words, structure numbers, station numbers, bid item numbers, work breakdown structure (WBS) and/or elevations in a concise and compact label in the MassDOT-Highway Division Contractor Construction Schedule Toolkit located on the MassDOT-Highway Division website at:

http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/Construction/ConstructionScheduleToolkit.aspx

G. ACTIVITY IDENTIFICATION NUMBERS

The Contractor shall use the activity identification numbering system specified in the MassDOT-Highway Division Contractor Construction Schedule Toolkit located online at the address above.

H. ACTIVITY CODES

The Contractor shall use the activity codes specified in the MassDOT-Highway Division Contractor Construction Schedule Toolkit located online at the address above.

I. CALENDARS

Different calendars may be created and assigned to all activities or to individual activities. Calendars define the available hours of work in each Calendar Day, holidays and general or project-specific non-Work Days such as Fish Migration Periods, time of year (TOY) restrictions and/or area roadway restrictions.

SECTION 722 (Continued)

Examples of special calendars include, but are not limited to:

- Winter Shutdown Period, specific work is required by separate special provision to be performed during the winter. See Special Provision 8.03 (if applicable)
- Peak traffic hours on heavily traveled roadways. This shall be from 6:30 am to 9:30 am and from 3:30 pm to 7:00 pm, unless specified differently elsewhere in the Contract.
- Special requirements by sensitive abutters, railroads, utilities and/or other state agencies as defined in the Contract.
- Cape Cod and the Islands Summer Roadway Work Restrictions: A general restriction against highway and bridge construction is enforced between Memorial Day and Labor Day, unless otherwise directed by the Engineer. Refer to the Project Special Provisions for specific restrictions.
- Cape Ann Summer Roadway Work Restrictions: While there are no general restrictions for Cape Ann as there are for Cape Cod and the Islands, project-specific restrictions may be enforced. Refer to the Project Special Provisions for specific restrictions.
- Turtle and/or Fish Migration Periods and/or other in-water work restrictions: Refer to the Project Special Provisions for specific restrictions.
- Working over Waterways Restricted Periods: Refer to the Project Special Provisions for specific restrictions.
- Night-time paving and striping operations, traffic and temperature restrictions: Refer to the Project Special Provisions for specific restrictions.
- Utility Restrictions shall be as specified within the Contract.

J. FLOAT

For the calculation of float in the CPM schedule, the setting for *Retained Logic* is required for all schedule submissions, starting with the Baseline Schedule Submission. Should the Contractor have a reason to propose that an alternative calculation setting such as *Progress Override* be used, the Contractor shall obtain the Engineer’s approval prior to modifying to this setting.

K. COST AND RESOURCE LOADING (Types A and B only)

For all Type A and B Schedules, the Contractor shall provide a cost and resource-loaded schedule with an accurate allocation of the costs and resources necessary to complete the Work. The costs and resources shall be assigned to all schedule activities in order to enable the Contractor to efficiently execute the Contract requirements and the Engineer to validate the original plan, monitor progress, provide cash flow projections and analyze delays.

1. Each schedule activity shall have an assigned cost that accurately represents the value of the Work. Each schedule activity shall have its resources assigned to it by craft and the anticipated hours to accomplish the work. Each schedule activity’s equipment resources shall be assigned to it by equipment type and hours operated. Front-loading or other unbalancing of the cost distribution will not be permitted.
2. The sum of the cost of all schedule activities shall be equal to the Contractor’s Bid Price.
3. Indicating the labor hours per individual, per day, by craft and equipment hours/day will be acceptable.
4. The Engineer reserves the right to use the cost-loading as a means to resolve changes, disputes, time entitlement evaluations, increases or decreases in the scope of Work, unit price renegotiations and/or claims.

SECTION 722 (Continued)

5. For all Type A and B Schedules, all subnets, fragnets, Proposal Schedules, and Recovery Schedules shall be cost and resource- loaded to help to quickly validate and monitor the duration of the Work to be performed.
6. For Type A Schedules, cost-loading of the schedule will also be used for cash flow projection purposes.
7. The cost-loading of each activity shall indicate the portion of the cost for that activity that is applicable to a specific bid item (cost account.) The total cost for each cost account must equal the bid item price.
8. For Type A Schedules, each month, the Contractor will be paid using the Cost-loaded CPM activities for Lump Sum payment items. This requirement supersedes any requirements elsewhere in this Contract regarding partial payments of schedule-of-values for all Lump Sum items.

L. NOT TO BE USED IN THE CONTRACTOR'S CPM SCHEDULE

1. Milestones or constraint dates not specified in the Contract
2. Scheduled work not required for the accomplishment of a Contract Milestone
3. Use of activity durations, logic ties and/or sequences deemed unreasonable by the Engineer
4. Delayed starts of follow-on trades
5. Float suppression techniques

722.62 Submittal Requirements

All schedules shall be prepared and submitted in accordance with the requirements listed below.

Each monthly Contract Progress Schedule submittal shall be uniquely identified.

Except as stated elsewhere in this subsection, schedule submittals shall include each of the documents listed below, prepared in two formats, for distribution as follows:

a. four (4) compact discs (CD); one (1) each for the Office of Project Controls and Performance Oversight (O-PC&PO), the Boston Construction Section Office, the District Construction Office and the Resident Engineer's Office. Additional copies shall be required if the work is performed in more than one district.
b. two (2) hard copies plotted in color on 24" X 36" paper; one (1) copy each for the District Construction Office and the Resident Engineer's Office. No copies for the O-PC&PO and the Boston Construction Section Office. Additional copies shall be required if the work is performed in more than one district.

SECTION 722 (Continued)

A. Narratives

A written narrative shall be submitted with every schedule submittal. The narrative shall:

1. itemize and describe the flow of work for all activities on the Critical Path in a format that includes any changes made to the schedule since the previous Contract Progress Schedule / Monthly Update or the Baseline Schedule, whichever is most recent;
2. provide a description of any specification requirements that are not being followed. Identify those that are improvements and those that are not considered to be meeting the requirements;
3. provide all references to any Notice of Delay that has been issued, within the time period of the Contract Progress Schedule Update, by letter to the Engineer. Note that any Notice of Delay that is not issued by letter will not be recognized by the Engineer. See Subsection 722.64.A - Notice of Delay;
4. provide a description of each third-party utility's planned vs. actual progress and note any that are trending late or are late per the durations and commitments as provided in the PUC Form; provide a description of the five (5) most important responses needed from the Department and the need date for the responses in order to maintain the current Schedule of Record;
5. provide a description of all critical issues that are not within the control of the Contractor or the Department (third party) and any impact they had or may have on the Critical Path;
6. provide a description of any possible considerations to improve the probability of completing the project early or on-time;
7. compare Early and Late Dates for activities on the Critical Path and describe reasons for changes in the top three (3) most critical paths ;
8. describe the Contractor's plan, approach, methodologies and resources to be employed for completing the various operations and elements of the Work for the top three (3) most critical paths. For update schedules, describe and propose changes to those plans and verify that a Proposal Schedule is not required;
9. describe, in general, the need for shifts that are not 5 days/week, 8 hours/day, the holidays that are inserted into each calendar and a tabulation of each calendar that has been used in the schedule;
10. describe any out-of-sequence logic and provide an explanation of why each out-of-sequence activity does not require a correction, if one has not been provided, and an adequate demonstration that these changes represent the basis of how these activities will be built, including considerations for resources, dependencies and previously-approved production rates;
11. identify any possible duration increases resulting from actual or anticipated unit price item quantity overruns as compared to the baseline duration, with a corresponding suggestion to mitigate any possible delays to the Critical Path. If the delay is anticipated to impact the Critical Path, refer to Subsections 4.06 - Increased or Decreased Contract Quantities and 8.10 - Determination and Extension of Contract Time for Completion and submit a letter to the Engineer notifying of a potential delay;
12. include a schedule log consisting of the name of the schedule, the data date and the date submitted.

SECTION 722 (Continued)

B. Bar Charts (Types A, B, C and D)

One (1) time-scaled bar chart containing all activities shall be prepared and submitted using a scale that yields readable plots and that meets the requirements of Subsection 722.61 - Schedule Content and Preparation Requirements Activities shall be linked by logic ties and shown on their Early Dates. Critical Paths shall be highlighted and Total Float shall be shown for all activities.

A second time-scaled bar chart shall also be prepared containing only the Critical Path or, if the Critical Path is not the longest path, the Longest Path using a scale that yields readable plots and that meets the requirements of Subsection 722.61 - Schedule Content and Preparation Requirements. Activities shall be linked by logic ties and shown on their Early Dates. Total Float shall be shown for all activities.

Bar Charts shall be printed in color and submitted on 11” X 17” paper or, if approved by the Engineer, as a .pdf file.

C. Detailed Activity Schedule Comparisons

A Detailed Activity Schedule Comparison (DASC) is a simple reporting tool in the format of a graphical report that will provide Resident Engineers with immediate, timely and up-to-date information. The DASC consists of an updated bar chart that overlays the current time period’s bar chart onto the previous time period’s bar chart for an easily-read comparison of progress during the present and previous reporting periods. The DASC shall be prepared and submitted in accordance with the instructions contained in the Construction Schedule Toolkit located on the MassDOT-Highway Division website at:

http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/Construction/ConstructionScheduleToolkit.aspx

The reports described in Subsections D, E and F below shall be submitted with all of the schedules listed in Subsection722.20 - General:

D. Activity Cost Report and Monthly Cash Flow Projections (Type A only)

With each Contractor Quantity Estimate (CQE), the Contractor shall submit an Activity Cost Report and Cash Flow Projection that includes all activities grouped by Contract Bid Item.

The Activity Cost Report shall be generated from the Schedule of Record and shall be the basis of the Monthly Cash Flow Projection. Within each contract Bid Item, activities shall be sequenced by ascending activity identification number and shall show:

1. activity ID and description,
2. forecast start and finish dates for each activity and,
3. when submitted as a revised schedule, actual start and finish dates for each completed activity.

For Unit Price pay items, in addition to the above, estimates to complete and any variance to the estimated Contract quantity shall be shown.

E. Resource Graphs (Type A only)

Monthly and cumulative resource graphs for the remaining Contract period using the Early Dates and Late Dates in the Contract Progress Schedule shall be included as part of each schedule submittal.

SECTION 722 (Continued)

F. Projected Spending Reports (Types B, C and D)

A Projected Spending Report (PSR) shall be prepared and submitted in accordance with the instructions listed at the end of this section. The PSR shall indicate the monthly spending (cash flow) projection for each month from NTP to Contractor Field Completion (CFC). Each month's actual spending shall be calculated using all CQEs paid during that month. If the difference between the Contractor's monthly projections vs. the actual spending is greater than 10%, the Contractor's monthly spending projection shall be revised and resubmitted within fifteen (15) Calendar Days.

The Projected Spending Report (PSR) shall be depicted in a tabular format and printed in color on 11 x 17-sized paper or larger as approved by the Engineer. For additional instructions and a template for preparing the Projected Spending Report (PSR), refer to the Contractor's Construction Schedule Toolkit located on the MassDOT-Highway Division website at:

http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/Construction/ConstructionScheduleToolkit.aspx or consult with the District Construction Scheduler.

722.63. Progress Schedule Requirements

A. Baseline Schedule

The Baseline Schedule shall be due thirty (30) Calendar Days after Notice to Proceed (NTP.) The Baseline Schedule shall only reflect the Work awarded to the Contractor and shall not include any additional work involving Extra Work Orders or any other type of alleged delay. The Baseline Schedule shall be prepared and submitted in accordance with Subsections 722.61 - Schedule Content and Preparation Requirements and 722.62 - Submittal Requirements. Once the Baseline Schedule has been accepted by the Engineer, with or without comments, it shall represent the as-planned schedule for the Work and become the Contract Progress Schedule of Record until such time as the schedule is updated or revised under Subsections 722.63.C - Contract Progress Schedules / Monthly Updates, 722.64.C - Recovery Schedules and 722.64.D - Proposal Schedules.

The Cost and Resource-Loading information (Types A and B only) shall be provided by the Contractor within forty-five (45) Calendar Days after NTP.

The Engineer's review comments on the Baseline Schedule and the Contractor's responses to them will be maintained for the duration of the Contract and will be used by the Engineer to monitor the Contractor's work progress by comparing it to the Contract Progress Schedule / Monthly Update.

B. Interim Progress-Only Schedule Submissions

The first monthly update of the Contract Progress Schedule/Monthly Update is due within seventy (70) Calendar Days after Notice to Proceed (NTP.) The Baseline Schedule review period ends at sixty (60) Calendar Days after NTP, see Subsection 722.60.B - Schedule Reviews by the Department. If the Baseline Schedule has not been accepted within sixty (60) Calendar Days after NTP, an Interim Progress-Only Schedule shall be due within seventy (70) Calendar Days after NTP. The purpose of the Interim Progress-Only Schedule is to document the actual progress of all activities, including non-construction activities, from NTP until the Baseline Schedule is accepted.

SECTION 722 (Continued)

C. Contract Progress Schedules / Monthly Updates (Types A, B, C and D)

The first Contract Progress Schedule shall be submitted by the Contractor no later than seventy (70) Calendar Days after NTP. The data date for this first Progress Schedule shall be sixty (60) Calendar Days after NTP. Subsequent Progress Schedules shall be submitted monthly.

Each Contract Progress Schedule shall reflect progress up to the data date. Updated progress shall be limited to as-built sequencing and as-built dates for completed and in-progress activities. As-built data shall include actual start dates, remaining Work Days and actual finish dates for each activity, but shall not change any activity descriptions, the Original Durations, or the Original Resources (as planned at the time of bid), without the acceptance of the Engineer. If any activities have been completed out-of-sequence, the Contractor shall propose new logic ties for affected in-progress and future activities that accurately reflect the previously-approved sequencing. Alternatively, the Contractor may submit to the Engineer for approval an explanation of why an out-of-sequence activity does not require a correction and an adequate demonstration that the changes accurately represent how the activities will be built, including considerations for resources, dependencies and previously approved production rates. Once approved by the Engineer, the Contractor may incorporate the changes in the next Contract Progress Schedule/Monthly Update with the affected activities clearly identified and explained in the Schedule Narrative.

No revisions to logic ties; sequence, description or duration of future activities; or planned resource costs shall be made without prior approval by the Engineer.

Any proposed logic changes for in-progress or future activities shall be submitted to the Engineer for approval before being incorporated into a Contract Progress Schedule. The logic changes must be submitted using a Proposal Schedule or a schedule fragnet submission. Once approved by the Engineer, the Contractor may incorporate the logic in the next Contract Progress Schedule/Monthly Update with the affected activities clearly identified and explained in the Schedule Narrative.

For any proposed changes to the original sequence, description or duration of future activities, the Contractor shall submit to the Engineer for approval an explanation of how the proposed description or duration change reflects how the activity will be progressed, including considerations for resources and previously approved production rates. Any description or duration change that does not accurately reflect how the activity will be progressed will not be approved by the Engineer. Once approved by the Engineer, the Contractor may incorporate the changes in the next Contract Progress Schedule/Monthly Update with the affected activities clearly identified and explained in the Schedule Narrative.

Except as otherwise designated by a Contract Modification, no Contract Progress Schedule that extends performance beyond the Contract Time and/or beyond any Contract Milestone shall be approved by the Engineer. The Contractor shall submit a Recovery Schedule if any Contract Progress Schedule/Monthly Update indicates a failure to meet the Contract Dates.

D. Short-Term Construction Schedule

The Contractor shall provide a Short-Term Construction Schedule that details daily work activities, including any multiple shift work that the Contractor intends to conduct, in a bar chart format. The daily activities shall directly correspond to the Contract Progress Schedule activities, with a matching reference to the activity identification number in the Contract Progress Schedule, and may be at a greater level of detail.

SECTION 722 (Continued)

The Short-Term Construction Schedule shall be submitted every two weeks. It shall display all work for a thirty-five (35) Calendar Day period consisting of completed work for the two (2) week period prior and all planned work for the following three (3) week period. The initial submission shall be provided no later than thirty (30) Calendar Days after NTP or as required by the Engineer.

The Contractor shall be prepared to discuss the Short-Term Construction Schedule, in detail, with the Engineer in order to coordinate field inspection staff requirements, the schedule of work affecting abutters and any corresponding work with affected utilities. Short-Term Construction Schedules shall be prepared and submitted in accordance with Subsections 722.61 - Schedule Content and Preparation Requirements and 722.62 - Submittal Requirements.

Failure to submit Short-Term Construction Schedules every two (2) weeks may result in withholding of full or partial payments by the Engineer.

722.64 Impacted Schedule Requirements

A. Notice of Delay

The Contractor shall notify the Engineer in writing, with copies to the District and State Construction Engineers, within three (3) Calendar Days of the start of any delays to the Critical Path that are caused by actions or inactions that were not within the control of the Contractor. Delay notifications that are not provided in a letter to the Engineer, such as a delay notification in the schedule narrative, will not be recognized as contractual notice in the determination of any Time Extension related to the impacts to the work associated with this specific alleged delay. Should such delay continue for more than one (1) week, the Contractor shall note it in the Schedule Narrative until the delay is no longer impacting the Critical Path for the completion of the Contract Milestones. The Engineer will evaluate the alleged delay and its impact and will respond to the Contractor within ten (10) Calendar Days after receipt of a notice of delay.

B. Time Entitlement Analysis

A Time Entitlement Analysis (TEA) shall consist of a descriptive narrative, prepared in accordance with Subsection 722.62.A - Narratives, and an as-built CPM schedule, which may be in the form of a schedule fragnet (that has been developed from the project's Contract Progress Schedule of Record, and illustrates the impact of a delay to the Critical Path, Contract Milestones and/or Contract Completion Date as required in Subsection 8.10 - Determination and Extension of Contract Time for Completion. TEAs shall also be used to determine the schedule impact of proposed Extra Work Orders (EWO) as also required in Subsection 8.10.

TEAs shall be prepared and submitted in accordance with the requirements of Subsections 722.61 - Schedule Content and Preparation Requirements and 722.62 - Submittal Requirements and shall be based on the Contract Progress Schedule of Record applicable at the start of the delay or impact from an EWO. A TEA fragnet must start with a specific new activity describing the work contained in either a Notice of Delay previously submitted to the Department per Subsection 722.64.A - Notice of Delay or an EWO.

SECTION 722 (Continued)

TEAs shall be submitted:

1. as part of any Extra Work Order that may impact Contract Time,
2. with a request for a Time Extension,
3. within fourteen (14) Calendar Days after a request for a TEA by the Engineer for any other reason.

A TEA shall be submitted to the Engineer before any Time Extension is granted to the Contractor. Time Extensions will not be granted unless the TEA accurately reflects an evaluation of all past delays and the actual events that occurred that impacted the Critical Path. The TEA must also demonstrate a plan for the efficient completion of all of the remaining work through an optimized CPM Schedule. The analysis shall include all delays, including Contractor-caused delays, and shall be subdivided into timeframes and causes of delays.

TEAs shall incorporate any proposed activities, logic ties, resource considerations, and activity costs required to most efficiently demonstrate the schedule impacts in addition to detailing all impacts to existing activities, logic ties, the Critical Path, Contract Milestones and the Contract Completion Date. In addition, TEAs shall accurately reflect any changes made to activities, logic ties, restraints and activity costs, necessitated by an Extra Work Order or other schedule impact, for the completion of the remaining work. The Contractor shall provide TEAs that demonstrate that all delays have been mitigated to the fullest extent possible without requiring an Equitable Adjustment to the original bid basis.

All TEAs shall clearly indicate any overtime hours, additional shifts and the resource that are proposed to be incorporated in the schedule. The Engineer shall have final discretion over the use of overtime hours and additional shifts. The Engineer shall have the right to require that overtime hours and/or additional shifts be used to minimize the duration of Time Extensions if it is determined to be in the best interest of the Department to do so.

When accepted, the changes included in a TEA shall be incorporated into the next Contract Progress Schedule per the requirements of Subsection 722.63.C - Contract Progress Schedules / Monthly Updates.

During the review of any TEA, all Contract Progress Schedules shall continue to be submitted as required.

The Engineer may request that the Contractor prepare a Proposal Schedule or a Recovery Schedule to further mitigate any delays that are shown in the accepted TEA/Contract Progress Schedule.

C. Recovery Schedules

The Contractor shall promptly report to the Engineer all schedule delays during the prosecution of the Work. Except as otherwise designated by a Contract Modification, no Contract Progress Schedule that extends performance beyond the Contract Time and/or beyond any Contract Milestone shall be approved by the Engineer. The Contractor shall submit a Recovery Schedule within fourteen (14) Calendar Days of a Contract Progress Schedule submission that shows failure to meet the Contract Dates. This requirement is critical to the Department’s ability to make informed decisions regarding Contract Time and costs.

SECTION 722 (Continued)

During the prosecution of the Work, should the Contractor's progress on a critical operation clearly not meet anticipated production, without cause by fault of the Department, or should a critical activity or series of activities not be staffed in accordance with the Contractor's approved Baseline Schedule resource planning, the Contractor shall be obligated to recover such delay. Recovery Schedules shall be prepared and submitted in accordance with Subsections 722.61 - Schedule Content and Preparation Requirements and 722.62 - Submittal Requirements within fourteen (14) Calendar Days of any of the cases listed above.

Recovery Schedules shall clearly indicate any proposed overtime hours, additional shifts, and the resources that are proposed to be incorporated into the schedule. The Engineer shall have final discretion over the use of overtime hours and additional shifts and shall have the right to require that overtime hours and/or additional shifts be used to minimize the duration of Time Extensions, without additional compensation for any Contractor delays, if it is determined to be in the best interest of the Department to do so.

During the review of any Recovery Schedule, all Contract Progress Schedules shall continue to be required every month.

The Engineer may request that the Contractor prepare a Recovery Schedule to further mitigate any delays that are shown in an accepted TEA/Contract Progress Schedule.

Changes represented in accepted Recovery Schedules shall be incorporated into the next Contract Progress Schedule.

D. Proposal Schedules

A Proposal Schedule is an alternative schedule used to evaluate proposed changes to the Contract scope or significant alternatives to previously approved approaches to complete the Work, which may include changes to activity durations, logic and sequence. For Types A and B Schedules, the Proposal Schedule shall be cost and resource-loaded.

A Proposal Schedule may be requested by the Department at any time or may be offered by the Contractor. The Engineer may request that the Contractor prepare a Proposal Schedule to further mitigate any delays that are shown in an accepted TEA/Contract Progress Schedule.

The Contractor shall submit the Proposal Schedule within thirty (30) Calendar Days of a request from the Department.

The Proposal Schedule shall not be considered a Schedule of Record until the logic, durations, narrative and basis of the Proposal Schedule have been accepted by the Engineer. If the Proposal Schedule took the form of a fragnet, it must be incorporated into the Contract Progress Schedule of Record showing the current progress of all other activities and the impacts/results of the changes made by the Proposal Schedule before the Proposal Schedule is accepted by the Department.

Proposal Schedules shall clearly indicate any proposed overtime hours, additional shifts, and the resources that are proposed to be incorporated in the schedule. The Engineer shall have final discretion over the use of overtime hours and additional shifts.

Changes represented in accepted Proposal Schedules shall be incorporated into the next Contract Progress Schedule. During the review of any Proposal Schedule, all Contract Progress Schedules shall continue to be required every month.

SECTION 722 (Continued)

E. Disputes (Types A, B, C and D)

All schedules shall be submitted, reviewed, dispositioned and accepted in the timely manner specified herein so as to provide the greatest possible benefit to the execution of this Contract.

Any dispute concerning the acceptance of a schedule or any other question of fact arising under this subsection shall be determined by the Engineer. Pending resolution of any dispute, the last schedule accepted by the Engineer will remain the Contract Schedule of Record.

COMPENSATION

722.80 Method of Measurement and Basis of Payment (Types A, B, C and D)

The Special Provisions will specify the fixed-price amount to be paid to the Contractor for the Project Schedule requirements contained herein. Each bidder shall include this lump-sum, fixed-price bid item amount in his/her bid. Failure to do so may be grounds for the rejection of the bid.

All required schedule-related work, including, but not limited to computers, computer software, the planning and coordination with utilities, training, schedule preparation and schedule submittals will be paid for under the fixed price amount.

This fixed price amount is for payment purposes only and is separate from what the Department considers to be the Contractor's General Condition costs. If the Contractor deems it necessary to include additional costs to provide all of the requirements of this section, these additional costs shall be included in the Contractor's overall bid price.

Twenty percent (20%) of this pay item will be paid upon the Engineer's acceptance of the Contractor's Baseline Schedule, prepared and submitted in accordance with Subsection 8.02.C.

The remaining eighty percent (80%) of this pay item will be paid in equal monthly installments distributed across the Contract Duration from Notice to Proceed (NTP) to Contractor Field Completion (CFC), less the 2 months required for the submittal and review of the Baseline Schedule in accordance with the following formula:

$$\text{Monthly Payment} = \frac{\text{Remaining Fixed Price amount (80\% of Item 100.)}}{\text{Contract Duration in whole months} - 2\text{ months}}$$

The timely and accurate submission of the Baseline Schedule is critical to the Contract and the Department's ability to make informed decisions. Only payments under Item 740 - Engineer's Field Office and Item 748 – Mobilization will be made until the Baseline Schedule is accepted by the Engineer.

SECTION 722 (Continued)

No payment for any other pay item will be processed beyond seventy-five (75) Calendar Days from Notice to Proceed (NTP) until the Baseline Schedule is accepted by the Engineer. Until the Engineer’s acceptance of the Baseline Schedule, the combined total of all payments made to the Contractor will be limited to an amount no greater than the total price for Item 748 - Mobilization or 3% of the contract price, whichever is less.

All Contract Progress Schedule Updates submitted later than ten (10) Calendar Days after the CQE (Contract Quantity Estimate) completion date, or greater than forty (40) Calendar Days from the Data Date of the previous submission, will be deemed to be no longer useful and will not qualify for payment. Late submittal of missed Contract Progress Monthly Updates will not result in recovery of the previously forfeited portion of the Schedule of Operations Fixed Price Payment Item.

Failure to submit schedules as and when required may result in the forfeiture of that portion of the Schedule of Operations Fixed Price Payment and/or the withholding of the full or partial CQE payments by the Engineer.

Failure to submit schedules that are acceptable to the Engineer may result in the forfeiture of that portion of the Schedule of Operations Fixed Price Payment and/or the withholding of the full or partial CQE payments by the Engineer.

The Schedule of Operations pay item will be adjusted to pay for only the actual quantity of schedules that have been submitted in accordance with this section.

The Contractor's failure or refusal to comply with the requirements of this Section shall be reasonable evidence that the Contractor is not prosecuting the Work with due diligence and may result in the withholding of full or partial payments by the Engineer.

Should there be a Time Extension granted to the Contractor, the Engineer may provide an Equitable Adjustment for additional Contract Progress Schedule Updates at intervals directed by the Engineer. Item 100. will be the basis for this Equitable Adjustment.

722.82 Payment Items

Item 100. SCHEDULE OF OPERATIONS - FIXED PRICE $42,000.00 LUMP SUM

ITEM 115.1 DEMOLITION OF BRIDGE NO.77.04 LS
ITEM 115.2 DEMOLITION OF BRIDGE NO. 79.81 LS

The work under this item shall conform to the relevant provisions of Section 112 and the following:

Work under Item 115.1 shall include the demolition, removal, and satisfactory disposal of bridge elements to the limits shown on the plans and as directed by the Engineer for Bridge 77.04. This item shall include, but not be limited to, complete demolition of the existing open timber deck, timber superstructure, timber abutments/dump walls, timber bents, and stone retaining walls; and partial demolition of the existing timber piles to the limits shown on the plans. This item also includes removal and disposal of crossties on the bridge approaches.

Work under Item 115.2 shall include the demolition, removal, and satisfactory disposal of bridge elements to the limits shown on the plans and as directed by the Engineer for Bridge 79.81. This item shall include, but not be limited to, complete demolition of the existing open timber deck, timber superstructure, timber dump walls, and timber bents; and partial demolition of the existing timber piles to the limits shown on the plans. This item also includes removal and disposal of crossties on the bridge approaches.

The Contractor shall contact the Housatonic Railroad a minimum of 21 days prior to demolition and request a list of the demolition materials that the Railroad will select to take ownership. All materials removed under this item and not selected to be kept by the railroad shall become the property of the Contractor and be properly disposed of in accordance with the Standard Specifications, these Special Provisions, and state and federal regulations.

The Contractor shall take all measures necessary to protect pedestrian and vehicular traffic from his construction operations. The Contractor shall coordinate with the Town and Police Department to determine if any police detail and temporary traffic management plan are required for the demolition. The Contractor is responsible for preparation and execution of traffic management plan, if required. Materials shall be removed carefully so as to avoid damage to adjacent structures and utilities. During the prosecution of this work, the Engineer may reject the use of any method or equipment, which causes undue vibration or possible damage to the remaining structure or any part thereof. No explosives shall be used.

The Contractor shall locate and protect from damage all existing utilities. The Contractor shall contact utility companies to verify existing utilities and locations and coordinate proposed utility locations prior to demolition and construction.

The Contractor shall obtain all necessary permits, coordinate with the utility owners the relocation of all utilities, and make all required submittals under this item prior to beginning any demolition work.

The Contractor shall be responsible for the disposal of wood as part of this contract. Disposal shall be accomplished through incineration of wood material at an approved facility. The processing and disposal facilities shall be fully licensed and permitted for handling, processing, storage and incineration of treated wood waste. Bottom ash, fly ash, and other by- product

residues from the combustion process shall be disposed of at a fully licensed landfill. Identified combustion facilities must be approved by MassDOT prior to the commencement of burning of disposed wood material.

The Contractor shall comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction and shall comply with ANSI A10.6 and NFPA 241.

The Contractor shall be responsible for reviewing the latest bridge inspection report and verifying that the existing bridge has the capacity necessary for any construction equipment that will be used on the existing bridge during construction. The Owner assumes no responsibility for structure to be demolished.

The Contractor shall schedule a Predemolition Conference at the Project site to review methods and procedures related to bridge demolition including, but not limited to, the following:

1. Inspect and discuss condition of construction to be demolished.
2. Review structural load limitations of existing bridge.
3. Review and finalize demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review and finalize protection requirements.
5. Review procedures for noise control and dust control.

The Contractor shall provide and maintain shoring, bracing, or structural support to preserve stability and prevent movement or collapse of construction being demolished.

Hazardous Materials: Hazardous materials may be present in structures to be demolished. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified or required by a licensed professional and/or agency having jurisdiction.

No demolition work shall be started until the various federal, state and local agencies and utility companies involved have been notified (not less than 7 days prior to the start of demolition) and the Contractor has received approval from the Engineer as to the equipment, procedures and schedule of operations during the demolition period.

Arrange demolition schedule so as not to interfere with Railroad's operations and temporary track panels shall be constructed in order to accommodate quick removal and replacement of track between the necessary shutdowns.

On-site storage or sale of removed items or materials is not permitted.

Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations.

Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas. Do not burn demolished materials.

Clean adjacent structures and improvements of dust, dirt, and debris caused by bridge demolition operations. Return adjacent areas to condition existing before bridge construction operations began.

SUBMITTALS

Demolition Procedure

The Contractor shall submit his proposed method of demolition for each structure, including crane capacity and location, demolition sequence, traffic management plan, schedule of operations, lift loads, equipment, tools, procedures, temporary supports, etc., to the Engineer for review. The submittal shall specify that the requirements for equipment and all procedures utilized shall be in conformance with the intent of Subsection 960.61D, Steel Erection of the Standard Specifications for Highways and Bridges. The demolition procedure and any necessary calculations (loads, selection of crane equipment, and lifting hardware) and drawings shall all be stamped by a Professional Structural Engineer registered in the Commonwealth of Massachusetts certifying that all existing structural members are suitably braced and supported throughout the demolition process. Work under this item may not commence until the Engineer has given written approval of the method of demolition.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The work described under Item 115.1 shall be paid for at the Contract lump sum price and shall include all labor, tools, equipment, materials, testing, loading, transportation, approvals, permits, police details, and preparation and execution of traffic management plan, and incidental work necessary for the completion of the work including any hazardous material costs.

The work described under Item 115.2 shall be paid for at the Contract lump sum price and shall include all labor, tools, equipment, materials, testing, loading, transportation, approvals, permits, police details, and preparation and execution of traffic management plan, and incidental work necessary for the completion of the work including any hazardous material costs.

ITEM 140.0 **BRIDGE EXCAVATION** **N/A**

The work to be done under these items shall conform to the relevant provisions of Section 140 of the Standard Specifications and shall consist of the excavation required for removal of the existing Br. 77.04 and Br. 79.81, for removal of existing retaining walls at Br. 77.04, for installation of the new precast bridge substructures for both bridges, approach slabs and tie rods for sheet piles for Br. 79.81 and riprap for Br. 77.04.

The excavated material will be transported and spread out within the railroad right-of-way by the Contractor. Approved areas for excavated materials will be determined by HRRC. The Contractor is responsible for disposal of the excavated concrete and stone masonry.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The work described under this section for Br. 77.04 shall be paid under Item 995.01. The work described under this section for Br. 79.81 shall be paid under Item 995.02.

ITEM 153 **RAPID SET FLOWABLE FILL** **CY**

GENERAL

The work to be done under this item shall conform to the relevant provisions of Section 901 and Section M4.08.0 of the Standard Specifications. The rapid set flowable fill will be used for backfilling the spaces below precast abutment caps of Bridges 77.04 and 79.81.

SUBMITTAL

Provide mix designs for review at least 14 days prior to need.

MATERIALS

Use materials that meet the requirements of Section 901 and Section M4.08.0 of the Standard Specifications.

MIX DESIGN

Rapid Set Flowable fill will consist of a mixture of Portland cement, fly ash, fine aggregate, air entraining admixture, and water. Use for the flowable fill is intended to allow for placement of backfill within 4 hours of mixture placement.

Rapid Set Flowable Fill shall have a minimum compressive strength of 1 psi at 1 hour, 10 psi at 3 hours, 35 psi at 16 hours and 50 psi in 28 days when cured under standard laboratory conditions. Report the laboratory compressive strength at these times as part of the mix design submittal.

DELIVERY, STORAGE, AND HANDLING

All delivery, storage, and handling shall conform to the relevant provisions of Section 901 and manufacturer's instruction.

Field penetrometer tests shall be performed by the contractor. Four hour field penetrometer tests shall have an average resistance strength of 400 PSI for each abutment; the Engineer may require up to 4 penetrometer tests per abutment. In the absence of a penetrometer test, the Engineer may subject the material to a load when a rod (reinforcing bar) approximately 1/2 inch or larger in diameter will not penetrate the in-place mix.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The quantity for Rapid Set Flowable Fill is the volume of flowable fill furnished and placed as prescribed and is measured by the cubic yard (CY) of flowable fill delivered to the job site and incorporated into the work as shown on the Plans, complete, and accepted.

Payment for the accepted quantity for Rapid Set Flowable Fill is full compensation for furnishing and placing the flowable fill material as specified or directed and includes proportioning, mixing, handling, hauling, placing, maintenance, and protection of the flowable fill; providing

admixtures, shoring, and forming; and all other materials, labor, equipment, tools, supplies, transportation, and incidentals necessary to necessary to complete the work in accordance with the Plans,
the Specifications, and other terms of the Contract. Payment for this item includes all direct and indirect costs and expenses necessary to complete the work.

ITEM 180.1 **HEALTH AND SAFETY PLAN** **LUMP SUM**

It is the Contractor's ultimate responsibility to ensure the health and safety of all the Contractor's employees and subcontracting personnel, the Engineer and his/her representatives, and the public from any on-site chemical contamination.

GENERAL

The HASP shall include the components required by OSHA 29 CFR 1910.120(b); be designed to identify, evaluate, and control health and safety hazards and provide for emergency response if needed; and be a dynamic document with provision for change to reflect new information, new practices or procedures, changing site environmental conditions or other situations which may affect site workers and the public.

Health and safety procedures provided by the Contractor shall comply with all the appropriate regulations that address employee working conditions (e.g. OSHA, RCRA, CERCLA). In addition, guidelines of NIOSH, OSHA, USCG, EPA, etcetera, shall be followed. Equipment used for the purpose of health and safety shall be approved and meet pertinent standards and specifications of the appropriate regulatory agencies.

The Contracor should also comply with the guilidelines and procedures as required on the website below:
COVID-19 guidelines and procedures for all construction sites and workers at all public work | Mass.gov

The Contractor shall fill and sign daily the MassDOT Contractor COVID-19 Daily Checklist in Appendix E, keep copies of the signed checklist and provide to MassDOT upon MassDOT's request.

The HASP shall be submitted to the Engineer for acceptance at least four weeks prior to commencement of work. The review and acceptance of the HASP by MassDOT does not relieve the Contractor of the responsibility for attaining the required degree of protection and training, or to comply with all laws, rules, regulations, standards or guidelines in effect during the execution of the contract.

A copy of the Health and Safety Plan shall be maintained on-site at all times by the Contractor. The on-site copy shall contain the signature of the Engineer and each on-site employee of MassDOT, Contractor and sub-Contractors. The employee's signature on the Health and Safety Plan shall be deemed prima facie evidence that the employee has read and understands the plan. A copy of the plan with signatures shall be submitted to the Engineer at the conclusion of the contract, or at the Engineer's request. Signature sheets shall be submitted monthly, or at the request of the Engineer.

49 CFR PART 219 COMPLIANCE

FRA's rule requires the Contractors and Subcontractors working on a railroad right-of-way be subject all 49 CFR Part 219 testing. MassDOT requires certification that the Contractor and

Subcontractors are in compliance with the requirements of 49 CFR Part 219. The Contractor and subcontractors must submit Compliance Plan to FRA. The FRA will send a letter acknowledging receipt (not approval) of the plan. Once received, a copy of the FRA acknowledgement letter is to be immediately forward to the MassDOT, along with certification from the contractor and subcontractors that their plan is in compliance with the requirements of 49 CFR Part 219. The FRA acknowledgement letter and contractor certification will be part of the compliance records.

The Contractor and Subcontractors will be prohibited from performing work until they are in compliance with 49 CFR Part 219. Any delays related to failure to comply with these requirements will be considered a non-excused delay under the contract.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Health and safety plan shall be measured by the lump sum, in accordance with the Plans, as specified herein and as directed by the Engineer.

Health and safety plan shall be paid for at the contract unit price per lump sum which shall be full compensation for all labor, and incidentals necessary for the development and preparation of the HASP and as directed by the Engineer.

ITEM 180.2 IMPLEMENTATION OF HEALTH AND SAFETY PLAN HOUR

For all construction activities that require handling or exposure to regulated soils, the Health and Safety Plan (HASP) shall specify an on-site Health and Safety Officer. The on-site Health and Safety Officer duties shall include, but are not limited to: implementation of the site Health and Safety Plan, training, evaluating risks, safety oversight, determining levels of personnel protection required, and performing any required monitoring at the site. A Daily Log shall be kept by the on-site Safety Officer and provided weekly to the Engineer. This log shall be used to record a description of the weather conditions, levels of personnel protection being employed, monitoring data and any other information relevant to on-site safety conditions. The on-site Health and Safety officer shall sign and date the Daily Log.

The level of protection, relative to respiratory and dermal hazards, required to ensure the health and safety of on-site personnel will be stipulated in the Health and Safety Plan and will be subject to modification by the on-site Safety Officer based on changing site and weather conditions and the following factors: type of operation or activity, chemical compounds identified on-site, concentration of the chemicals, physical state of the hazardous materials, potential duration of exposure to hazardous materials, dexterity required to perform work, decontamination procedures, necessary personnel and equipment, and type of equipment to be utilized.

The Contractor shall be required to provide appropriate personnel protective equipment for anyone who is working in an area either containing or suspected of containing a hazardous environment. This work will include both individuals physically working in these areas and those directing the work of same. Contingencies for upgrading the level of protection for on-site workers will be identified in the Health and Safety Plan and the Contractor shall have the necessary materials/equipment on hand to implement the level of protection upgrade in a timely manner. Payment for this level of upgraded protection shall be paid for under Item 180.3.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Implementation of health and safety plan shall be measured by the hour, as specified herein and as directed by the Engineer.

Implementation of health and safety plan shall be paid for at the Contract unit price per hour which shall be full compensation for all labor and incidentals necessary to employ an on-site health and safety officer to implement the HASP when regulated soils are encountered, to complete the work, as specified herein, as shown on the Contractor developed HASP, and as directed by the Engineer. This shall be full compensation for all time required for both on-site and any off-site report preparation, travel time shall be incidental. The Engineer shall have final say as to the number of hours charged to the project.

ITEM 180.3 FULL TIME SAFETY SUPERVISOR N/A

The Contractor shall have a full-time (all working hours/one each shift) on-site experienced Safety Supervisor, whose sole responsibility is on-site safety management.

Safety Supervisor shall successfully complete HRRC Roadway Worker Protection and qualification.

The Contractor shall within thirty (30) days after receipt of the award of the contract submit the resume of the qualifications and work experience of the designated Safety Supervisor proposed for assignment to the Project and evidence of their successful completion of Roadway Worker Protection and qualification. No construction work shall begin until the project Safety Supervisor has been approved by MassDOT.

The Safety Supervisor shall have a minimum of 5 years of experience as a construction safety supervisor, three of which include full-time on-site construction safety experience. Qualifications shall include:

- Thorough knowledge of construction safety and OSHA regulations
- Successful completion of OSHA 30 hour Construction Safety and Health training course
- Specialized safety training relevant to the project
- Demonstrated ability in creating a safe work environment
- Working knowledge of safety regulations and hazard control measures
- Demonstrated ability to conduct safety training
- Working knowledge of safety specific contract hazardous work procedures
- Physically able to perform the job
- Thorough knowledge of Title 49 Part 213 Track Safety Standards, Subparts A to F
- Thorough knowledge of Housatonic Railroad On-Track Safety Manual
- Thorough knowledge of applicable Provisions of Title 49 CFR Part 214 Railroad Workplace Safety, as promulgated by the Federal Railroad Administration (FRA), in particular:
    - Subpart B-Bridge Worker Safety Standards
    - Subpart C-Roadway Worker Protection
    - Subpart D-Track Roadway Maintenance machines and Hi-Rail Vehicles

The duties of the Safety Supervisor shall include maintenance of the Contractor's safety program, enforcement of safe practices, and the use of safety equipment and personal protective equipment, and other such activities as may be required by OSHA and MassDOT to maintain job safety and accident prevention. The safety representative shall not be replaced, terminated, nor reassigned without the written approval of MassDOT. A minimum transition of two weeks shall occur. Vacancies in these positions must be filled within two weeks of the vacancy occurring. The Safety Representative shall be assigned full-time to the contract and shall not be utilized concurrently on any other MassDOT contract or any other projects outside this MassDOT contract.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Separate Measurement and Payment will not be made for the work of this Special Provision. All costs for ITEM 180.3 FULL TIME SAFETY SUPERVISOR shall be considered incidental to the Work.

ITEM 180.4 FULL TIME QUALITY CONTROL SUPERVISOR N/A

The Contractor shall have a full-time on-site experienced Quality Supervisor, whose sole responsibility is on-site quality management, including management of the Contractor's Quality Program.

Quality Control Supervisor shall successfully complete HRRC Roadway Worker Protection and qualification programs.

The Contractor is responsible for controlling the quality of Work including work of its Subcontractors and suppliers and for assuring that the specified quality is achieved. The Contractor, Subcontractors and suppliers shall establish, maintain, and implement a written Quality Assurance Program (QAP). The Contractor shall ensure their Quality Assurance Program includes a responsibility to audit themselves plus all subcontracts, fabricators, and suppliers. The Contractor shall note that MassDOT reserves its right to also perform audits. The Program shall be tailored to the scope and complexity of the Work and shall include implementing procedures and inspection forms equal to or more detailed than those included at the end of this Section and throughout the Special Provisions.

The Contractor shall within thirty (30) days after receipt of the award of the contract submit their QAP, the resume of the qualifications and work experience of the designated Quality Supervisor proposed for assignment to the Project and evidence of their successful completion of Roadway Worker Protection training and qualification. No construction work shall begin until the QAP and project Quality Supervisor have been approved by MassDOT. The Quality Supervisor shall have at least five (5) years of experience in implementing a quality control program on construction projects of similar size, scope and complexity. The Quality Supervisor shall be technical competent with the freedom and authority to make decisions without pressure or bias and shall have sufficient authority to ensure that quality requirements are consistently maintained.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Separate Measurement and Payment will not be made for the work of this Special Provision. All costs for ITEM 180.4 FULL TIME QUALITY SUPERVISOR shall be considered incidental to the Work.

Daily Quality Field Report
Contractor
Berkshire Line Track Improvement - Phase III
Contract Number: 117189

Prepared By:		**Date Prepared:**	
Weather:		**Daily Report Date:**	

Quality Activities Observed: Provide a Brief Description of Quality Activities Performed

Permanent Material Installed & Products Used			
Material	**Purpose**	**Location**	**Submittal #**

Quality Checks/Inspections/3rd Party Inspections	
Material	**Purpose**

Quality Manager:	Signature:	Date:

ITEM 190.01 GEOTECHNICAL INSTRUMENTATION FOR BRIDGE NO. 77.04 N/A

ITEM 190.02 GEOTECHNICAL INSTRUMENTATION FOR BRIDGE NO. 79.81 N/A

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. This Section specifies surveying, furnishing, installing, protecting, reading, reporting, maintaining and removing instrumentation as part of a Geotechnical Monitoring Program required for evaluation of ground movements during construction, and their effects on adjacent structures. The locations of all instruments and monitoring points shall be as specified herein. The Work includes implementing required remedial and precautionary measures based on instrumentation data.

B. Geotechnical instrumentation shall be provided for monitoring of the following activities:

1. Excavations for construction activities.
2. Vibration-producing activity.
3. Sheet pile and pile installation.

C. Geotechnical instrumentation shall be provided for the following structures and facilities:

1. Bridge 77.04
2. Track on Bridge 77.04 and at approaches
3. Bridge 79.81
4. Track on Bridge 79.81 and at approaches

D. The purpose of this program is to provide data that, when used with other observations and measurements, will be the basis of:

1. Evaluating the performance of the existing bridges and tracks during construction of the replacement bridges.

E. Work in connection with the Geotechnical Monitoring Program shall include, but not necessarily be limited to the following:

1. Furnishing and installing geotechnical instrumentation and respective readouts.
2. Surveying, monitoring, reporting and interpreting instrumentation data.

F. Instrumentation Layout

1. Locations and types of instruments to be installed shall be as specified herein. The Contractor shall submit a plan of the instrumentation layout meeting these requirements.
2. Engineer reserves the right to modify the instrument layout as is deemed necessary to monitor the impact of the Contractor's proposed method of construction.

G. Related work specified elsewhere:

1. ITEM 140– BRIDGE EXCAVATION
2. ITEM 942.144 – STEEL PILE HP 14X117
3. ITEM 495.10 – DRILLED MICROPILES
4. ITEM 952 – STEEL SHEET PILE

H. MASSDOT and the Housatonic Railroad are not responsible for the safety of the Work based on data from the Contractor's or the Engineer's monitoring program.

1.2 QUALITY ASSURANCE

A. All equipment shall be approved by the Engineer.

B. Materials, designs and construction shall be of highest quality to provide robust, corrosion and vibration resistant instruments. Accuracy and dependability of equipment shall be selected considering changes in temperature, humidity, stray currents or other adverse conditions that may be encountered.

C. Installation procedures acceptable to the Engineer shall be developed for each type of instrumentation. All instrumentation shall be installed in the presence of the Engineer.

D. Qualifications

1. Manufacturer: Select a firm regularly engaged in the manufacture of monitoring instrumentation of the type specified herein.
2. Personnel:
   a. Geotechnical Instrumentation Engineer: Employ a Professional Engineer, registered in the Commonwealth of Massachusetts, specializing in geotechnical engineering, who has experience in installation of instruments of the type specified in this Section in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer. The Contractor's Geotechnical Instrumentation Engineer shall supervise and direct instrument installation technicians and shall be responsible for instrument installation and monitoring, and reduction and interpretation of instrumentation monitoring data.
   b. Qualified geotechnical instrumentation personnel must be available on call at all times during the work that would affect geotechnical instrumentation.
   c. Provide a Land Surveyor, Registered in the Commonwealth of Massachusetts, responsible for layout and subsequent verification of all instrument locations and elevations.

E. Tolerances

1. Establish the initial coordinates of each instrument at the point of installation to 0.01 foot or less.
2. Establish the initial elevation of settlement reference points to 0.005 feet. Achieve level circuit closure with an error of closure of 0.01 foot, or less.

F. The Engineer may perform supplemental monitoring of instrumentation and will require Contractor support as follows:

1. Make probes, sensors, and read-out devices available as required.
2. Coordinate activities to minimize interference.
3. Remove obstructions from line of sight when requested by the Engineer.
4. Temporarily cease activities that create hazards to instrument monitoring or surveying personnel.

A factory calibration shall be conducted on all instruments prior to shipment. Certification shall be provided to indicate that the test equipment used for this purpose is calibrated and maintained in
accordance with the test equipment manufacturer's calibration requirements and that, where applicable, calibrations are traceable to the National Institute of Standards and Technology.

H. A final quality assurance inspection shall be made prior to shipment. During the inspection, a checklist shall be completed to indicate each inspection and test detail. A completed copy of the checklist shall be supplied with each instrument.

I. Contractor shall provide the manufacturer's warranty for each portable readout unit furnished for the Engineer's monitoring program.

1.3 SUBMITTALS

A. Qualifications:

1. Submit qualifications of Land Surveyor, Registered in the Commonwealth of Massachusetts, and Geotechnical Instrumentation Engineer.

B. Working Drawings:

1. Submit Working Drawings of instrumentation location layout and details before installation. Indicate methods of installation and maintenance for instrumentation systems.

C. Documentation:

1. Submit manufacturer's catalogs and printed installation instructions for instruments furnished.
2. Submit, within 24 hours of completion of equipment installation, three copies of installation notes, initial readings, and monitoring data taken immediately after installation.

D. Certification:

1. Submit certification of equipment manufacturers at least 21 calendar days prior to installation.
2. Submit certificates of equipment calibration.

E. Monitoring Documentation:

1. Unless otherwise provided by the Engineer, submit proposed forms to be used for recording observations, and monitoring and reporting data. Submit a sample showing proposed format for recording of readings, calculations and plots.

2. Submit the following within 12 hours after monitoring any instrument:

   a. A copy of the data sheet containing a cumulative history of all readings, including weather conditions at time of each reading.
   b. A copy of the plot of measured value versus time, which also includes a time history of construction activity likely to influence such readings (e.g., depth of excavation, presence of heavy equipment).

3. Each week the Contractor shall submit to the Engineer a weekly data report together with all new data on a CD or by e-mail, in Excel or other spreadsheet format approved by the Engineer.

1.4 RESPONSIBILITIES OF CONTRACTOR

A. Furnish components of instrumentation that are to be installed during construction, portable readout units for the Contractor's use, portable readout units for the Engineer’s use, and install instruments. The Contractor shall protect and maintain installed instruments and replace or repair damaged or inoperative instruments.

B. Maintain and calibrate portable readout units. Maintain readout unit(s) at the Site for use by the Engineer.

C. Collect, reduce, process, plot, interpret, and report data from instrumentation; henceforth the monitoring program.

D. Provide safe access to the Engineer for data collection. Coordinate with the Engineer to verify the consistency of collected data. Implement remedial measures based on interpretations of monitoring program data.

E. Contractor is responsible for obtaining all necessary permits for installation of all specified instruments.

1.5 JOB CONDITIONS

A. Disclosure of Instrumentation Data:

   1. Do not disclose instrumentation monitoring data to third parties and do not publish instrument monitoring data without the prior approval of the Engineer. The data from the instrumentation program shall be the property of MASSDOT.

   2. Be responsible for interpretation of instrumentation data as input to evaluating excavation performance and controlling settlements to prevent damage to structures, facilities and utilities.

   3. The Engineer will also interpret the instrument monitoring data and will make the interpretation available to the Contractor.

B. Determine exact location of the instruments to be installed in the field with approval of the Engineer.

C. Access to Instruments: Provide and facilitate safe access to each instrument for the Engineer at all times. Access includes ladders, working platforms and other necessary facilities, and the removal thereof.

1.6 MONITORING SCHEDULE

A. All equipment and installation accessories required for operation of instrumentation system and recording of measurements shall be furnished by Contractor and shall be available at least four (4) weeks in advance of construction in the area where they are to be installed and shall be securely stored where they will not suffer physical damage or damage arising from excessive moisture, extremes of temperature or other adverse conditions.

B. Contractor shall provide and maintain adequate lighting and provide a safe means of access to all instruments to allow installation, repair, and reading of instruments at times selected by Engineer.

C. Structural deformation monitoring points (DMPs) shall be installed and initial surveys completed a minimum of two (2) weeks prior to any construction activity related to excavation or installation of sheet piles or steel piles.

D. The instruments shall be monitored in accordance with the requirements of Table 1 specified herein.

E. If, in the opinion of Engineer, there appears to be excessive movement, the monitoring points shall be surveyed as often as deemed necessary by Engineer, at no additional cost to MASSDOT.

F. Monitoring for Track Movement

See Aritcle 3.8 TRACK MONITORING PROGRAM in this Special Provision.

PART 2 - PRODUCTS

2.1 MATERIALS FOR INSTRUMENTATION

A. All instrumentation hardware, protective covers, read-out equipment, and equipment and materials necessary to conduct the monitoring program shall be purchased or rented by the Contractor. Prior to installation, all materials and equipment shall be available for inspection by the Engineer to ensure compliance with these specifications.

B. Surface protection shall be flush with the ground surface in paved or other areas.

C. For each instrument type, provide an instruction manual that shall include the following:

1. A description of the purpose of the instrument.
2. Theory of operation.
3. Step-by-step procedures for:
    a. Pre-installation acceptance test when instruments are received on site, to ensure the instruments are functioning correctly prior to installation.
    b. Calibration of readout units.

4. A list of calibration equipment required, and recommended frequency of calibration.

5. Step-by-step instrument installation procedure including materials, tools, spare parts and any borehole requirements, and post-installation acceptance tests.

6. Maintenance procedure.

7. Step-by-step data collection procedure.

8. Data reduction, processing, and plotting procedures.

D. All graduations shall be in U.S. Customary Units, for example feet, inches, pounds.

2.2 DEFORMATION MONITORING POINTS

A. Deformation monitoring points (DMPs) shall be used to monitor vertical and horizontal deformation of various facilities at selected locations specified herein.

B. The following types of DMPs shall be used to monitor deformation:

1. DMPs shall be used to monitor movements of structures, and shall consist of a 5/16 in. dia. x 4-1/2 in. long (or longer) hex bolt, ASTM A307-UNC Thread, screwed into a 1 in. long x 5/16 in. dia. tamp in screw anchor (for stone masonry structures) or threaded screw anchor (for timber structures). The anchor and the casing shall meet the requirements of Federal Specification FF-S-325 Group 1, Type 1, Class 1. A 5/16 in. dia. x 3/4 in. long carriage bolt shall replace the 4-1/2 in. long (or longer) hex bolt when readings are not being taken. These screw anchors shall typically be installed into surfaces of structures. Alternatively, reflective survey prisms may be used as structural DMPs.

2. Survey Pins (SP) along the side of existing tracks to identify locations of track monitoring. Paint marks on the sides of the rails may be used with written permission from MASSDOT and the Housatonic Railroad.

2.3 CRACK MONITORS

A. Provide portable comparator/reticule crack monitor system, with linear scale 0.75 in. long, graduated every 0.005 in., and a triplet lens to create a flat optical field over the entire reticule area. Alternatively, displacement transducers may be used to monitor cracks.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All instruments shall be installed in the presence of the Engineer. Cooperate with the Engineer to allow safe access to the work area at all times for the purpose of observing instrumentation installation.

B. Contractor's Geotechnical Instrumentation Engineer shall be fully responsible for the installation, testing, calibration, reading, and maintenance of the instrumentation, interpretation of the field readings and

implementation of appropriate corrective measures. Verify the reliability of all installed instruments a minimum of 2 weeks prior to construction.

C. Location and arrangement of the instrumentation shall be planned so that monitoring can continue until completion. Adequate access for maintenance and reading of the instrumentation shall be provided.

D. All instruments shall be securely fixed such that they are capable of resisting movement and pressure changes underground, or vandalism and adverse climatic conditions at surface locations.

E. The Contractor shall install, monitor, and interpret data from instrumentation, in addition to that specified herein, that the Contractor deems necessary to ensure the safety of personnel and the Work, at no additional cost to MASSDOT. Data shall be reported to the Engineer as specified herein.

F. Maintain records relating to problems encountered, delays, unusual aspects of the installation, and details of any events that may have a bearing on instrument behavior. These records should be submitted along with monitoring data.

3.2 INSTALLATION OF INSTRUMENTS

A. Install the equipment according to the manufacturers' recommendations.

B. Testing shall be undertaken as necessary to ensure satisfactory functioning of the equipment at each stage of the installation.

C. Instruments found to be malfunctioning at any time shall be replaced within one week.

3.3 INSTALLATION OF DEFORMATION MONITORING POINTS

A. Deformation monitoring points (DMPs) including survey pins (SP) shall be installed per the approved plan, and as directed by the Engineer. As a minimum, DMPs shall be installed on bridge bents, dump walls, and retaining walls.

B. At least three DMPs (one near each end and one near the center) shall be located on each bridge bent and dump wall to monitor differential settlement and rotation of the structures.

C. DMPs shall be located on retaining walls at a spacing not to exceed 10 feet on center.

D. After installation of a DMP, determine as-built location in horizontal position to an accuracy of +/- 0.01 ft, and in elevation to an accuracy of +/- 0.005 ft.

3.4 INSTALLATION OF CRACK MONITORS

A. Cracks, gaps betwwen ends of existing timber stringers over bents and connections to be monitored on structures shall be identified and marked clearly for identification purposes at locations determined by the pre-construction survey performed by the Contractor and as approved by the Engineer.

B. The initial reading of crack monitors where installed shall be documented and photographed with date stamp.

3.6 MAINTENANCE OF INSTRUMENTATION

A. Prevent damage to the instruments and ancillary equipment during handling, installation and subsequent operation. Maintain all the instruments required for long term monitoring in a satisfactory working order for the duration of the monitoring program. Should an instrument become damaged or become nonfunctional, it shall be the Contractor's responsibility to replace, within one week, the damaged instrument to the satisfaction of the Engineer at no additional cost to MASSDOT.

B. Ensure that all the instrumentation in use has been correctly calibrated. Carry out periodic checks to confirm the validity of calibration of equipment in accordance with the manufacturer's instructions and carry out any adjustments that are found necessary. Suspect readings shall be repeated.

C. Keep records of all calibration certificates and, when necessary, send equipment off site for re-calibration by an independent accredited testing laboratory.

D. Record the location of all instrumentation on as-installed Working Drawings. As-installed drawings shall include the routing of all cabling. Hidden electrical instrumentation shall be identifiable by color codes and/or tagged cables. The reference coding shall also be recorded on the as-installed drawings.

E. Ensure that electrical instrumentation is not adversely affected by other temporary or permanent electrical services.

3.7 INSTRUMENT READING AND RECORDS

A. Instruments shall be read as soon as possible after installation to establish datum readings that shall be established from a minimum of two independent reading operations giving consistent results. The method of reading shall be as recommended by the manufacturer.

B. Monitoring Schedule

1. Monitor instrumentation in accordance with the schedule shown in Table 1.
2. Monitor instrumentation more frequently, if instrumentation detects significant anomalous or suddenly changing readings.

C. In the event of any change in circumstances, for example the influence of the construction of other structures nearby, the program of readings shall recommence.

D. The same recording devices shall be used at any given location through the monitoring program. If forany reason this becomes impracticable, due to instrument breakage for example, new datum readings shall be taken immediately with a replacement instrument, and the new instrument used for the future readings. Similarly, should a monitoring location become unavailable, the instrument previously read from this point shall, within one week, be read from an alternative point, the latter then being used for subsequent readings.

E. Readings shall, wherever possible, be taken by the same personnel. Should the personnel be replaced for any reason, a series of duplicate readings shall be carried out by the out-going person and the replacement.

3.8 TRACK MONITORING PROGRAM

A. Monitoring points shall be set up one week before pile driving or excavation operations begin. MassDOT and HRRC shall be notified when monitoring points have been established. Elevation readings to establish the initial baseline readings shall begin two days prior to the start of pile driving. Obtain additional baseline survey readings immediately after track panel replacement or surfacing operations in order to establish new baseline values. All future elevation readings shall be compared to the adjusted baseline. Clearly indicate new baseline measurements and events requiring new baseline measurements in data sheets and plots. If the track deviates to a condition that is unacceptable to MassDOT or HRRC, corrections shall be made at the Contractor's expense.

B. Monitoring points shall be spaced at 15.5 foot intervals. Determine and record the top of rail elevations and horizontal position along each rail at each monitoring point. Monitoring area shall include the area of pile driving and excavations. Monitoring area shall exend at least four points beyond the work area and at least 100 feet beyond locations of excavation or vibration-producing construction activity. Include additional monitoring points centered over each bent and abutment.

C. Elevation readings shall be taken a minimum of once per eight hour shift from the beginning of excavation, sheet pile, and pile installation until all work is backfilled and completed. Readings shall be taken more frequently if limiting values are exceeded. After pile installation and backfilling to finished line and grade is complete, readings shall be taken weekly for two weeks, and one final reading shall be taken prior to the end of the Contract.

D. Monitoring readings shall be e-mailed to MassDOT and HRRC on a daily basis. All information shall be presented in legible reduced form for easy review. Readings that do not comply with track tolerances shall be highlighted. All costs associated with monitoring and any track adjustments shall be borne by the Contractor with no compensation by the Owner.

E. Track Tolerances

1. Horizontal Track Alignment .. . . +/- 0.25-inch
2. Vertical Track Profile .. . . +/- 0.25-inch

3.9 LIMITING INSTRUMENTATION READINGS

A. The Contractor shall perform all work in a manner to prevent instrumentation readings from exceeding limiting values specified in Table 2. Where the Contractor's operations result in instrumentation readings approaching the limiting values in Table 2, the Contractor shall modify his means and methods so that the work may be accomplished without exceeding the limiting values. Any delays or modifications to the Contractor's means and methods shall be at no additional cost to MASSDOT.

3.10 DATA REDUCTION, PROCESSING, PLOTTING AND REPORTING

A. The Contractor's instrumentation personnel and surveyors shall reduce, process, plot, and report data from the Contractor's monitoring program.

B. Each week the Contractor shall submit to the Engineer a weekly data report together with all new data on a CD or by email, as specified herein. The weekly data report shall be bound and indexed and shall include:

1. A section for each type of instrument. This section shall include: a brief description of the cumulative changes in instrument readings, a brief description of the changes in readings from the previous weekly data report, a table summarizing instruments, actual readings, and if any limiting readings have been reached. Raw and reduced data collected during the week, on summary tables (8-1/2in. x 11in. sheets of paper). Plots of data versus time and including key construction activities and other events that could influence changes in the data shall be shown. Plots of like instruments shall be done at the same scale to facilitate graphical comparison.

2. A description of work being performed during the week by the Contractor and any possible activity in the area that may have an effect on instrument readings. Describe groundwater control and temporary relief operations, including pump locations, times of operation, and estimated quantity of flow.

3.11 DAMAGE TO INSTRUMENTATION

A. The Contractor shall protect all instruments and appurtenant fixtures, leads, connections, and other components of instrumentation systems from damage due to construction operations, weather, traffic, and vandalism.

B. If an instrument is damaged or inoperative, including an existing instrument installed by others, the Contractor's instrumentation personnel shall repair or replace the damaged or inoperative instrument within 72 hours, at no additional cost to MASSDOT. The Engineer will be the sole judge of whether repair or replacement is required. The Engineer may impose a work stoppage in the vicinity of the damaged or inoperative instrument until it is again operational, at no additional cost to MASSDOT.

C. Contractor shall repair or replace at its own cost any of the readout devices used for the Contractor's monitoring program that become damaged, inoperative, or, in the judgment of the Engineer, unreliable.

3.12 REMOVAL OF INSTRUMENTS

A. Prior to completion of the Contract, remove all instrumentation installed under this Contract. Protect and maintain all instrumentation until such time as written approval authorizing removal of instrumentation has been received from the Engineer.

B. Removal of instruments shall include removing and disposing of protective covers, and recovery of salvageable portions of instrumentation.

C. All instruments or portions thereof removed by the Contractor shall remain the property of the Contractor.

D. Instrumentation readout and calibration equipment purchased under this Contract shall become the property of MASSDOT.

E. Remove the instrumentation specified herein as directed by the Engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

1. Work under Item 190.01 for Br. 77.04 and Item 190.2 for Br. 79.81 shall be paid at the contract unit price per lump sum under Items 950.01 Bridge Structure, Bridge No. 77.04 and Item 950.02 Bridge Structure, Bridge No. 79.81, respectively. Payment for these Items, including the design, all necessary equipment, materials and installation, monitoring and reporting, maintenance and removal, all as outlined above, shall be included in the Contract Lump Sum Price for these items.

TABLE 1: MONITORING SCHEDULE

INSTRUMENT	SCHEDULE
All Instruments	(1) One reading immediately after installation. (2) One reading each workday until, as determined by the Engineer, repeatability indicates that any data changes resulting from the installation process have ceased. (3) Formal initial reading. (4) One reading immediately prior to any construction activity. Thereafter, reading frequency shall follow the schedule given below.
Railroad Track Monitoring Points	See Article 3.8 TRACK MONITORING PROGRAM in this Special Provision.
Crack Monitors	One reading every sheet pile (pair) installation, every pile installation and every week in between sheet pile and pile installation until all sheet piles and piles are installed. Readings shall be taken once daily if limiting values are exceeded and until the readings have equilibrated to the satisfaction of the Engineer. Readings will continue to be taken weekly until the existing bridges are demolished.
Structural Deformation Monitoring Points	One reading every sheet pile (pair) installation, every pile installation and every week in between sheet pile and pile installation until all sheet piles and piles are installed. Readings shall be taken once daily if limiting values are exceeded and until the readings have equilibrated to the satisfaction of the Engineer. Readings will continue to be taken weekly until the existing bridges are demolished.

TABLE 2: LIMITING INSTRUMENTATION READINGS

INSTRUMENT	**LIMITING VALUE**
Railroad Track Monitoring Points	Horizontal ± 0.25 inches; Vertical ± 0.25 inch
Structural Deformation Monitoring	± 0.5 inch
Crack Monitors	None (1)

TABLE 2 NOTES:

1. Crack monitor data shall be evaluated by the Contractor in conjunction with DMP data.

ITEM 458.6.1 **FURNISH BALLAST** **TON**

GENERAL

These Specifications describe requirements for the furnishing, testing, and procurement of ballast to be used in areas of track reconstruction, and for aligning and surfacing track. Ballast shall meet, in every respect, specifications of the American Railway Engineering and Maintenance-of-Way Association (AREMA) contained in the Manual for Railway Engineering, Volume 1, Chapter 1, Part 2 – Ballast, Sections 2.2 through 2.6 standards. Ballast shall be installed at locations per the Contract plans and at the direction of the Engineer.

SUBMITTALS

1. Prior to shipment of ballast, submit the name of the ballast supplier, processing facility and testing laboratory that will sample and test the ballast as in AREMA, Chapter 1, Tables 1.2.1 and 1.2.2 to the Engineer for review and approval.
2. Prior to shipment of ballast, submit inspection reports certifying that all required tests and inspections as specified herein have been made and that the ballast being shipped is in full compliance with AREMA specifications and as specified herein to the Engineer for review and approval.
3. Prior to shipment of ballast, submit a certification that field samples were secured in accordance with the current ASTM Methods of Sampling Designation D75, and that test samples were reduced from field samples by the means of ASTM C702 to the Engineer for review and approval.
4. Required testing includes, but is not limited to:
    a. Sieve Analysis: ASTM Method of Test Designation C136
    b. Material Finer than No. 200 Sieve: ASTM Method of Test Designation C117
    c. Bulk Specific Gravity: ASTM Method of Test Designation C127
    d. Absorption: ASTM Method of Test Designation C127
    e. Percentage of Clay Lumps and Friable Particles: ASTM Method of Test Designation C142
    f. Resistance to Degradation: ATSM Method of Test
    g. Designation C535 - Material gradations with particles retained on 1” sieve
    h. Designation C131 - Material gradations with 100% passing the 1” sieve
    i. Sodium Sulfate Soundness: ASTM Method of Test Designation C88
    j. Unit Weight: ASTM Method of Test Designation C29
    k. Percent of Flat and/or Elongated Particles: ASTM Method of Test Designation D4791

5. For each ballast sample obtained, test results shall be entered in the **Field Inspection Summary Report** included in this specification and submitted to the Engineer for review and approval prior to the shipment of ballast.
6. Sampling and testing of ballast as specified herein shall not be billed separately, but are included in the cost per ton of ballast supplied to MassDOT.

Submit the following for review and approval by the Engineer before ballast work is started:

1. List of proposed equipment for use in construction. The list shall be submitted to the Engineer twenty one (21) days prior to the start of work and shall include the name of the manufacturer, dimensions and weights of the equipment and the intended use of each of piece of equipment.
2. Proposed construction and installation procedures for ballast installation, and track surface and alignment.
3. Manufacturer’s certificate of compliance to the Engineer for all materials that are incorporated into the work.

QUALITY ASSURANCE

1. Provide certified test results of ballast quality and grading as conducted by the approved testing laboratory.
2. In addition, provide tests for gradation (sieve analysis) for every 1,000 tons of ballast delivered to the job site.
3. Testing, as defined by this specification, shall be performed at least two (2) times a year or as directed by the Engineer, to ensure the quality of the material being produced. If the supplier changes the location of the source or encounters changes within the supply source, laboratory testing shall be performed on the new material to ensure compliance with specifications.
4. Field samples shall be secured in accordance with the current ASTM Methods of Sampling, Designation D75. Test samples shall be reduced from field samples by the means of ASTM C702.
5. If the source of ballast changes during ballast installation, additional certified test results (in accordance with the requirements included under Submittals and Quality Assurance) shall be provided to the Engineer for review and approval prior to the shipment of the ballast from the new source.
6. Supplier shall certify with billing that the ballast delivered is typical of the ballast which has been tested and that has been approved by the Engineer.
7. Perform sampling and tests of the ballast material to determine compliance with specified requirements. Samples shall be initially taken from the supplier’s source (quarry). Additional samples may be taken from the site at the direction of the Engineer.

PRODUCTS

PRODUCTS AND MATERIALS TO BE PROVIDED BY HOUSATONIC RAILROAD COMPANY (HRRC)

1. None

PRODUCTS AND MATERIALS TO BE PROVIDED BY THE CONTRACTOR

1. All Ballast

MATERIALS

1. Ballast shall conform to AREMA Number 4 Gradation.
2. Ballast shall be crushed, quarried, and washed Granite or Traprock composed of hard, strong, angular, and durable particles, free from frozen lumps, foreign materials, and injurious amounts of substances and conforming to all of the requirements of these specifications.
3. Ballast shall conform to the following Limiting Values:

No.	Property	Ballast Material	
		Granite	**Traprock**
1.	Sieve Analysis	AREMA No. 4	AREMA No. 4
2.	Percent Material Passing No. 200 Sieve	1.0%	1.0%
3.	Bulk Specific Gravity See Note 1 below	2.60	2.60
4.	Absorption Percent	1.0	1.0
5.	Percent Clay Lumps and Friable Particles	0.5%	0.5%
6.	Degradation Percent	35%	25%
7.	Soundness (Sodium Sulfate) 5 Cycles (Percent Material Loss)	5.0%	5.0%
8.	Unit Weight (lb/ft^3)	By Engineer	By Engineer
9.	Percent Flat and/or Elongated Particles	5.0%	5.0%
	Note 1: Use ASTM Test Designation most representative of ballast material gradation as specified above. Note 2: The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.		

EXECUTION

DELIVERY OF BALLAST

1. Contractor is responsible for coordinating delivery of ballast, including the delivery schedule. Contractor shall coordinate delivery windows and track access required for ballast delivery with HRRC.
2. Contractor shall provide HRRC written notice a minimum of two weeks prior to the date ballast will be delivered to the site.
3. The Contractor is responsible for all ballast delivered by rail or truck.
4. See ITEM 850.42 WORK TRAINS for locomotive support available from HRRC for moving ballast cars within the project corridor.
5. Contractor is responsible for all scheduling and coordination for ballast delivery. MassDOT is not responsible for delays or any additional costs associated with delivery of ballast, all costs shall be the responsibility of the Contractor.

PRODUCTION AND HANDLING

1. The ballast production facility shall be of such a design to permit production and blending without excessive working of the materials. The capacity of the production facility shall be adequate to efficiently produce the anticipated daily loadings providing sufficient stockpiles to facilitate loadings without any delays.
2. Blending, stockpiling and other production and handling operations shall be managed by the producer to keep ballast clean and minimize segregation of the finished product. Stockpiling operations shall minimize the breakage or excessive fall in stockpiling

operations. The movement of wheeled or tracked machines over stockpiled materials shall be limited.

3. Processed ballast shall be washed and/or rescreened as necessary to remove fine particle contamination as defined by the specification prior to stockpiling, in operations using stockpiles, or immediately prior to loading operations.

LOADING

1. Processed ballast shall be loaded only into rail cars or trucks which are in good order, tight enough to prevent leakage and waste of material, and clean and free from rubbish or any substance which would foul the ballast.

INSPECTION

1. MassDOT, or its representatives, reserve the right to make unscheduled visits to the supplier's facility during normal business hours for the following purposes:
    a. Observe sampling and testing procedures to assure compliance with the requirements of these specifications.
    b. Obtain representative samples of the prepared material being produced and shipped.
    c. Review plant inspection, methods, quality control procedures, and equipment and review test results of both current and previous tests.
2. The supplier shall provide MassDOT or its representative with such assistance, materials, and laboratory testing equipment as necessary to perform so called "on site production tests" consisting of site gradation and percent passing No. 200 sieve.
3. Performance of these tests at the time of an unscheduled inspection visit is the right, but not the duty, of the inspector.

CONSTRUCTION QUALITY CONTROL AND ASSURANCE

ACCEPTANCE/REJECTION

1. To be accepted, ballast offered shall conform to this specification in all respects. Ballast is also subject to inspection at delivery and is at the supplier's risk until acceptance. Ballast rejected for non-compliance with this specification will be picked up, loaded and transported off-site at the supplier's expense. Ballast installed prior to acceptance and subsequently rejected for non-compliance with this specification shall be removed and replaced at the Contractor's expense. MassDOT is not responsible for any costs associated with rejection of ballast.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The Contractor shall provide all necessary labor, equipment and materials to be incorporated into the work as indicated on the Contract Drawings and in these Special Provisions.

Work under ITEM 458.6.1 FURNISH BALLAST shall be measured and paid at the contract unit price per TON under ITEM 458.6.1 FURNISH BALLAST. Contractor shall submit weight tickets to the Engineer for all ballast furnished. No payment will be made without weight tickets being submitted to the Engineer.

MassDOT Rail Division
FIELD INSPECTION SUMMARY REPORT
To Be Submitted by Supplier

Ballast Supplier:	**Sample Location:**
Quarry Location:	**Sample No./Type:**
Date Sampled:	**Testing Company:**

Field samples were secured in accordance with the current ASTM Methods of Sampling Designation D75. Test samples were reduced from field samples by the means of ASTM C702.

Supplier's Authorized Signature

TEST	ASTM STANDARD		ALLOWABLE RESULT/RANGE		TEST RESULT	PASS/ FAIL	COMMENTS
1. Sieve analysis AREMA No. 4	C136		UL %	LL %			
Ballast Material ❑ Granite (G) ❑ Traprock (T)	% Passing	2"	-	100%			
		1 ½"	100%	90%			
		1"	55%	20%			
		¾"	15%	0			
		½"	N/A	N/A		N/A	
		⅜"	5%	0			

TEST	ASTM STANDARD	LIMITING VALUE	TEST VALUE	PASS/ FAIL	COMMENTS
2. Percent Material Passing No. 200 Sieve	C117	1.0%			
3. Bulk Specific Gravity	C127	2.60			
4. Absorption Percent	C127	1.0			
5. Percent Clay Lumps and Friable Particles	C142	0.5%			
6. Degradation Percent	❑C131/❑C535	G-35% /T-25%			
7. Soundness (Sodium Sulfate) 5 Cycles (Percent Material Loss)	C88	5.0%			
8. Unit Weight (lb/ft^3)	C29	By Engineer			
9. Percent Flat and/or Elongated Particles	D4791	5.0%			

ITEM 492.2 **FURNISH TRACK SPIKES** **KEG**

GENERAL
This section specifies the requirements for track cut spikes.

All work and materials shall conform to AREMA Manual for Railway Engineering, Chapter 5 and AREMA Portfolio of Trackwork Plans.

Contractor shall supply all necessary cut spikes to complete the work specified. Coordination with the HRRC personnel shall be required for access to location for material stockpiles.

SUBMITTALS

1. Certificates of Compliance shall be provided for all materials furnished by the Contractor.
2. Submit shop drawings of track cut spikes for review and approval by the Engineer.
3. Any Contractor-furnished materials which are installed in track and subsequently found to be defective shall be replaced by the Contractor at no additional cost to the Project.

QUALITY ASSURANCE

The dimensions and general arrangement of all track materials shall conform to AREMA Manual for Railway Engineering.

PRODUCTS

MATERIALS TO BE FURNISHED BY THE CONTRACTOR

1. Track cut spikes furnished by the Contractor shall be new, five-eighths of an inch (5/8") x six inches (6") long, cut spikes conforming to the requirements of the AREMA Manual for Railway Engineering, Volume 1, Chapter 5, Part 2 with the dimensions specified in "Design of Cut Track Spike."

EXECUTION

EXAMINATION

The Engineer may examine any materials furnished by the Contractor for defects, damage, or non-conformance prior to installation. Materials not meeting the requirements of the Specifications or that are determined to be damaged or defective shall be removed from the project site and shall be replaced by acceptable materials at no additional cost to the Project.

HANDLING

1. Track Spikes shall be delivered in kegs.

2. Installation of all track spikes shall be included in the appropriate bid items.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Contractor shall furnish track spikes. Work under ITEM 492.2 FURNISH TRACK SPIKES shall be measured and paid at the contract unit price per KEG under ITEM 492.2 FURNISH TRACK SPIKES.

All other labor and material required to complete work within this section shall be considered incidental to the contract work or the item it pertains.

ITEM 492.3 CLEANUP AND DISPOSAL OF CROSSTIES BRIDGE TIMBER, AND WOOD MATERIALS NA

DISPOSAL REGULATIONS

Wood materials are to be disposed in accordance with local, State and Federal regulations. The Contractor shall notify MassDOT which facility will be used to dispose of crossties, bridge timber, and wood materials. A copy of the Mass DEP certification showing that it is an approved disposal facility along with all weight slips for crossties/timbers sent to an approved facility shall be provided to MassDOT.

1. REMOVALS/DEMOLITION

   The Contractor shall remove and dispose of materials to the limits indicated in the Contract Drawings and these Special Provisions.

   a. Non-contaminated and contaminated materials shall be disposed of at a certified disposal facility. The Contractor shall provide the weight slips and other documentation as required for the disposal of all materials.
   b. Disposal of all ties/timber removed from track during general tie/timber replacement and track rehabilitation at a certified and registered facility. Pieces of ties may have to be picked up by hand and/or raked up to be loaded out for disposal.

DISPOSAL OF OLD CROSSTIES

The Contractor is responsible for the cleanup of all crossties, bridge timber and switch timber on the right-of-way including those from previous crosstie installation projects. All old crossties and timbers are to be picked up and disposed of at a Mass DEP approved disposal site as specified in the Special Provisions. Wood pickup is to be done concurrently with installation of crossties.

1. Disposal of Materials

   a. Dispose of scrap ties and timber.
   b. Disposal of all ties/timber removed from track during general tie replacement and track reconstruction at a certified and registered facility.
   c. The Contractor to obtain:

      i. Weight tickets from certified facility giving tie tonnage, trucker, truck number and date brought to the plant.
      ii. Corresponding truck tickets used by haulers to remove ties from project and transferred to certified facility.
      iii. Tickets from (a) and (b) must match and will be used to determine actual payment to the Contractor.

d. Small pieces of removed ties will not be allowed to remain on the right-of-way. Pieces of ties may have to be picked up by hand and/or raked up to be loaded out for disposal.

PRODUCTION RATES

Scrap crossties, bridge timber, and other wood products shall be removed from the right of way within five (5) working days of their removal from the track.

Piles of scrap crossties, bridge timber, and other wood products are permitted at locations agreed upon between the Contractor and the Railroad. Such staging piles must be removed within thirty (30) days of completion of the crosstie installation phase of this Contract.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The Contractor shall provide all necessary labor, equipment and materials to complete the work as indicated on the Contract Drawings and in these Special Provisions including, but not limited to, pickup of materials, disposal of materials, and maintaining the Work Area in a neat and orderly fashion.

Separate Measurement and Payment will not be made for the work of this Special Provision complete in place. All costs associated with Bridge No. 77.04 shall be included in ITEM 115.1 DEMOLITION OF BRIDGE NO.77.04. All costs associated with Bridge No. 79.81 shall be included in ITEM 115.2 DEMOLITION OF BRIDGE NO.79.81. All preparation and incidental work necessary to accomplish the installation will be considered incidental to ITEM 115.1 DEMOLITION OF BRIDGE NO.77.04 and ITEM 115.2 DEMOLITION OF BRIDGE NO.79.81 and will not be meassured or paid seperately.

ITEM 492.8 SURFACE AND ALIGN BALLASTED TRACK TRACK FOOT

GENERAL

This Section specifies the requirements for placing track ballast stone and for surfacing and aligning the track. Work includes general procedures for modifications in existing track and reconstructed track areas. Work includes:

1. Initial and final surfacing and aligning of tracks
2. Track ballast compaction
3. Track Raises

Related work specified elsewhere includes:

1. ITEM 458.6.1 – FURNISH BALLAST

REFERENCE STANDARDS

1. Current American Railway Engineering and Maintenance of Way Association (AREMA), Manual for Railway Engineering, Chapter 1.

SUBMITTALS

1. Submittals will be reviewed for general conformance with the intent of the Contract Documents. This review will not relieve the Contractor of final responsibility for the means, methods, procedures, and sequences to be used.
2. The following submittals shall be made to the Engineer for review and approval prior to procuring any material or performing any work required under this Section:
   a. A detailed description of the methods and procedures to distribute, tamp, regulate and compact ballast for track surface and alignment work.
   b. Submit type and specifications for equipment to be used in the placing, compacting, and tamping of track ballast and for aligning of track.
3. Upon completion of final surfacing and aligning produce as-built charts from tamper or liner and submit to the Engineer for approval.

MECHANIC

1. A Qualified Mechanic shall be on site at all times during construction operations including surfacing. The mechanic shall be equipped with a truck that contains sufficient tools, replacement parts, and fluids for the equipment being used.

QUALITY ASSURANCE

1. Testing of ballast at the production facility and on the job-site shall be performed in accordance with ITEM 458.6.1 FURNISH BALLAST.

2. Tolerances: Track construction tolerances show below shall not be exceeded.

PRODUCTS

PRODUCTS AND MATERIALS TO BE PROVIDED BY MASSDOT

1. None.

PRODUCTS AND MATERIALS TO BE PROVIDED BY THE CONTRACTOR

1. Ballast by ITEM 458.6.1 FURNISH BALLAST.

EXECUTION

LINE AND GRADE

1. Final track line shall conform to the existing track line to the extent possible except as indicated otherwise in the Contract Drawings.
2. The final grade and profile shall be as indicated in the Contract Drawings.

CONSTRUCTION TOLERANCES

1. Final surface, aligning and gauge of track shall be within the following tolerances:

Track Surface and Alignment

Construction Tolerance	**(Inches)**
Deviation from uniform profile on either rail at the midordinate of a 62 ft. chord shall not exceed	± 1/4”
Deviation from zero cross level at any two points less than 62 ft. apart on tangents or specified elevation on curves shall not exceed	± 1/8”
The difference in cross level between any two points less than 62 ft. apart on tangents or curves shall not exceed	± 1/4”
Deviation from uniform alignment between any two points less than 62 ft. apart on tangent and curved track shall not exceed	± 1/4”

2. There is no reverse elevation allowed in curves. Curves shall be elevated as follows:

a. Elevation shall be run out in spirals as indicated on the Contract Documents.

b. The actual elevation in a curve shall be within +⅛" and -0" of the design value.

3. Gauge of track shall be 56½" (± 1/8").

4. The Contractor, at no cost to the Project, shall correct any deviations from the above specified tolerances. Contractor shall also provide update as-builts as needed at no cost to the Project.

RUNOFF – VERTICAL ALIGNMENT

1. The runoff at the end of a raise into a hold point in track, such as at the project limits location, shall not exceed 1-1/2 inch in 31 feet of track unless otherwise approved by the Engineer.

SURFACING AND ALIGNING

1. Ballasting

   a. Following installation of initial layers of ballast and assembly of reconstructed track (By ITEM 492.11.1 TRACK RECONSTRUCTION), unload ballast in tie cribs and shoulders of track structure.

   b. Unload ballast in quantities which will fill tie cribs and provide an adequate amount of ballast for the initial track raise with sufficient surplus to continue to hold track after initial raise.

   c. Prior to dumping ballast in track, ties shall be properly spaced as specified and shall be square with rails.

   d. Contractor shall re-space and straighten ties as required before stone is distributed.

   e. The Contractor shall use a ballast regulator machine to distribute the stone ballast in sufficient quantity for tamping the track and for restoring the ballast section.

   f. The Contractor shall avoid pulling sod, vegetation, and other foreign material onto the track structure or shoulders for purpose of tamping or dressing the ballast section. Any sod, vegetation or foreign matter inadvertently pulled in shall be removed by the Contractor prior to tamping.

   g. Clean the track way area of all debris and standing water prior to placing of ballast. Do not place ballast on frozen subgrade or subballast.

   h. Deliver ballast at a rate no faster than can be satisfactorily incorporated into the work.

   i. To the extent practicable, unload ballast in position for use with a minimum of redistribution and dressing.

2. Tamping

a. Tamp ballast with 16 tool, squeeze-vibratory type, power tamping equipment. Control of power tamper shall ensure maximum compaction of ballast uniformly along track. The Engineer will determine tamping variables, including rate of advance, number of passes, number of insertions per tie (minimum of two required), length and number of blades, and frequency of vibration. Tamping tools shall be replaced when the working surface is worn more than 30 percent of its original surface area. Procedures and equipment shall be as approved. To allow for proper insertion depth below bottom of crossties, the tamping tools shall be adjusted to compensate for concrete/timber crosstie size difference.

b. Tamp ballast thoroughly under both sides of tie from a point 15 inches inside rails to ends of tie.

c. For each tie, tamp simultaneously inside and outside both running rails on both sides of tie. Minimum tamping insertions shall be two per tie.

d. The Contractor shall remove ties at locations selected by the Engineer, in order that the Engineer may inspect ballast compaction beneath ties. If compaction does not meet requirements of these Specifications, additional ties shall be pulled at the Engineer's direction to discover limits of inadequate tamping. Areas of inadequate tamping shall be resurfaced at no additional cost to MassDOT.

e. Tamping on snow covered or frozen ballast will not be permitted.

3. Initial Surfacing and Aligning

a. Surface and align track to achieve horizontal and vertical alignment as specified herein and as shown on the Contract Drawings.

b. Initial surfacing and aligning shall be performed to bring track geometry to within one inch of final profile and to within one inch of final alignment.

c. Surface and align track by methods which will prevent undue bending of rail, straining of joints, or damaging of rail fastening assemblies.

d. Surface and align track only after cribs are filled with ballast.

e. The amount of track lift in a single pass shall not exceed three inches or endanger horizontal and vertical stability of tracks.

f. Perform as many raising and surfacing passes of three inches or less as needed to bring track surface to within one inch of final design elevation as indicated in the Special Provisions and the Contract Drawings.

g. Restore ties pulled loose during surfacing to full bearing against rail and properly secure them.

h. Remove and replace any ties, fasteners, or OTM damaged during surfacing operations with new ties, fasteners, or OTM at no additional expense to MassDOT.

4. Final Surfacing and Aligning

   a. Final surfacing and aligning of track shall be completed after track has been initially surfaced and aligned.

   b. Surface and align track to meet Class 3 specifications per FRA Track Safety Standards Part 213 and the Contract Documents.

   c. Final surfacing and aligning shall be performed to bring the track to final grade and alignment and to comply with surface and superelevation tolerances specified and shall consist of a lift of one inch maximum unless otherwise directed by the Engineer or indicated on the Contract Drawings.

   d. During final track raise, line track to final alignment. Track liner employed shall be a fully automatic model capable of determining existing curve data, computing new values for optimum curve value, and lining track to the new values without disturbing track surface. Machine shall be capable of producing a tape or graph showing existing and proposed values and this tape shall be reviewed and approved by the Engineer prior to final lining. Tape shall become the property of MassDOT.

5. Ballast Compaction and Ballast Dressing

   a. Concurrent with both initial and final surfacing and aligning of all tracks and turnouts, consolidate cribs and shoulders and dress ballast to conform to ballast section shown on Contract Drawings and as directed by the Engineer.

   b. After final surfacing and alignment of track is completed, consolidate cribs and shoulders and dress ballast to conform to ballast section shown on the Contract Drawings. Top of ballast shall be one inch below base of rail. Ballast shoulders shall be 18” minimum on tangents. Shoulder width shall not be reduced without prior approval of the Engineer.

   c. Subbase outside toe of slope of ballast that has been fouled or disturbed by Contractor's operations shall be properly sloped as shown on Contract Drawings and as directed by the Engineer.

   d. Upon completion of final surfacing and aligning produce as-built chart from tamper or liner and submit to the Engineer for approval.

FINAL TRACK INSPECTIONS

1. Final horizontal and vertical alignment, gauge, superelevation and cross level shall be within the tolerances specified. In order to determine the acceptability of finished track, the Contractor together with MassDOT, and at the Contractor’s expense, shall conduct a final inspection to establish that track construction is within tolerances specified in ITEM 492.8 SURFACE AND ALIGN BALLASTED TRACK.

2. Track deviations disclosed by inspection, which exceed tolerances specified herein, shall be corrected by the Contractor at no additional cost to MassDOT. Reinspections shall be made by the Contractor and MassDOT to ensure that corrections have been made.
3. Final inspection shall include testing by equipment capable of testing gauge, cross level, left and right rail profiles, track alignment, twist, warp and superelevation. Equipment shall be capable of measuring the parameters specified above with sufficient accuracy to establish that the track construction is within the specified tolerances. Contractor shall submit for approval the proposed equipment to be used, and who will be conducting the testing, prior to the start of the work. Records of all testing and results shall be submitted to the Engineer.
4. Notify the Engineer one month in advance regarding the request for the scheduling of final track inspections.
5. The Contractor shall participate in any retesting, required as a result of corrections to work, at no additional cost to MassDOT. Cost of MassDOT approved equipment required for retesting shall be the sole responsibility of the Contractor.

MEASUREMENT AND PAYMENT

The Contractor shall provide all necessary labor, equipment and materials to be incorporated into the work as indicated on the Contract Drawings and in these Special Provisions.

Work under ITEM 492.8 SURFACE AND ALIGN BALLASTED TRACK shall be measured and paid at the contract unit price per TRACK FOOT under ITEM 492.8 SURFACE AND ALIGN BALLASTED TRACK.

ITEM 492.11.1 TRACK RECONSTRUCTION TRACK FOOT
ITEM 492.11.2 HANDLING AND DISPOSAL OF EXCAVATION SPOILS N/A

GENERAL

This section applies to track reconstruction in the area designated as remove and reset 107# rail as indicated on the Contract Drawings.

This section specifies the removal and reconstruction of track on the bridge and bridge approaches including rail, OTM, cross ties, ballast, ballast mat and geotextiles.

SUBMITTALS

All submittals shall be approved before any work may proceed. Contractor shall submit the following for review and approval:

1. Proposed Protection Measures: Submit informational report in accordance with OSHA Part 1926 procedures, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and for noise control. Indicate proposed locations and construction of barriers.
2. Indicate the following:
    a. Detailed sequence of demolition work.
3. Contractor shall submit for approval the facility to be used for the disposal of crossties.
4. A detailed construction work plan describing the methods and procedures to be used in the execution of TRACK RECONSTRUCTION as specified herein, including:
    a. Proposed construction and installation procedures for ballasted track construction, ballasted track panel removal and installation, tie installation, tie plate removals and replacements, and track surface and alignment.
    b. Proposed methods to distribute, tamp, regulate and compact ballast for track reconstruction and track surface and alignment.
5. Prior to bringing equipment to the job site, submit list of equipment proposed for use in construction, including tie installation equipment for removing and installing timber ties and removing wood bridge timbers. The list shall be submitted to the Engineer fifteen (15) days prior to the start of work and shall include the name of the manufacturer, dimensions, type, age, present condition, and weights of the equipment and the intended use of each piece of equipment.
6. The Contractor shall furnish resumes for the Superintendent and Foremen who are to be employed in the Work to the Engineer for review and approval prior to the start of Work.

7. Submit for approval product specifications for ballast mat and geotextile protection layer, the manufacturer's installation requirements, and the Contractor's plan for the complete installation.

QUALITY ASSURANCE

GENERAL

1. The Contractor shall perform all measures necessary to assure the quality of the Work. This shall include quality control and field quality control requirements specified in these special provisions.
2. Prepare a quality control plan for the Work to be performed for review and approval by the Engineer prior to start of work.
3. Contractor shall implement a comprehensive quality assurance program to assure that the Work is performed as specified in the Contract Documents.
4. Contractor's Quality Assurance program shall be supervised by the full time quality control supervisor (See Item 180.4 FULL TIME QUALITY CONTROL SUPERVISOR.
5. Track construction tolerances shall be in compliance with ITEM 492.8 SURFACE AND ALIGN BALLASTED TRACK.
6. Except as modified by these Special Provisions or the Contract Drawings, trackwork construction and materials shall conform to the current AREMA Manual for Railway Engineering and AREMA Portfolio of Trackwork Plans.

REQUIRED CONTRACTOR SUPERVISION

1. The FULL TIME QUALITY CONTROL SUPERVISOR shall be on site during crosstie installation and quality control operations overseeing, instructing. and assuring quality workmanship. If multiple sites/bridges are under construction at the same time, Contractor shall submit for review and approval the qualifications for additional Full Time Quality Control Supervisors as necessary, one (1) per site.
2. One (1) Qualified Foreman is to be on site during operations. If multiple sites/bridges are under construction at the same time, Contractor shall provide additional Foremen, one (1) per site. Qualified Foreman will work to ensure that quality deficiencies are addressed prior to the next step in the production sequence. Foremen are to be on the ground directly supervising the production process. Performing tasks that do not support this purpose shall not be permitted. The Qualitied Foreman shall have at least five (5) years of experience as a foreman on construction projects of similar size, scope and complexity.

REQUIRED AMOUNT OF PERSONNEL

1. The Contractor shall have on site at all times a sufficient number of qualified Machine Operators to ensure safe operation and quality workmanship.
2. The Contractor shall ensure there is a sufficient number of Laborers to perform all

tasks as needed for crosstie, bridge timber, and QC operations.

MECHANIC

1. A Qualified Mechanic shall be on site at all times during construction operations. The mechanic shall be equipped with a truck that contains sufficient tools, replacement parts, and fluids for the equipment being used.

FINAL TRACK INSPECTIONS

1. The final surface, alignment, gauge, cross level, and superelevation shall be within the tolerances as specified in these Special Provisions.
2. In order to determine the acceptability of finished track, the Contractor and Engineer shall make a final inspection to establish that track construction is within the tolerances specified herein and obtain approval of the Engineer.
3. Track deviations, as disclosed by the inspection described above, which exceed tolerances specified herein shall be corrected by the Contractor at no additional cost to the Project.
4. The Contractor shall make necessary re-inspections to confirm that corrections have been made.
5. The Contractor shall notify the Engineer one week in advance before requesting any track inspection.

PRODUCTS

PRODUCTS AND MATERIALS TO BE PROVIDED BY MASSDOT

1. Timber crossties
2. Replacement tie plates and joint bars that are not suitable for reuse as determined by the Engineer. Tie plates and joint bars damaged by the contractor shall be replaced at no cost to MassDOT.
3. Rail anchors.

PROCUCTS AND MATERIALS TO BE PROVIDED BY HOUSATONIC RAILROAD COMPANY

1. 107# relay plug rail as required.

MATERIALS FURNISHED BY THE CONTRACTOR

1. Ballast by ITEM 458.6.1 FURNISH BALLAST.
2. Track spikes by ITEM 492.2 FURNISH TRACK SPIKES
3. Nuts, bolts, and washers in conformance with AREMA .
4. Ballast mat and geotextile protection layer.

5. All additional materials not specifically cited as being provided by MassDOT or HRRC shall be provided by the Contractor and considered incidental to the work described in this section.

BALLAST MAT

1. Approach Ballast Mat: Pandrol Under Ballast Mat UBM-H80-S or approved equal (one layer mat).
2. Bridge Deck Ballast Mat: Pandrol Under Ballast Mat UBM-H22-S or approved equal (two layer mat).
3. Non Woven Geotextile Protection Layer for Ballast Mat: In accordance with requirements of ITEM 492.14 GEOTEXTILE MATERIALS.

MATERIALS

SUBBALLAST/GRAVEL BORROW

1. Submittals:
   a. Prior to shipment of subballast, submit the name of the subballast supplier, processing facility and testing laboratory that will sample and test the subballast to the Engineer for review and approval.
   b. Submit test results for the following required testing, which includes but is not limited to:
      i. Particle Size Analysis: ASTM Method of Test Designation D422
      ii. Material Finer than No. 200 Sieve: ASTM Method of Test Designation C117
      iii. Absorption: ASTM Method of Test Designation C127
      iv. Percentage of Clay Lumps and Friable Particles: ASTM Method of Test Designation C142
      v. Resistance to Degradation: ATSM Method of Test Designation C131 - Material gradations with 100% passing the 1” sieve
      vi. Unit Weight: ASTM Method of Test Designation C29
      vii. Sampling and testing of subballast as specified herein shall not be billed separately, but are included in the cost per ton of subballast supplied.
2. Quality Assurance:
   a. Provide certified test results of subballast quality and grading as conducted by the approved testing laboratory.
   b. Testing, as defined by this specification, shall be performed at least two times a year or as directed by the Engineer, to ensure the quality of the material being produced. If the supplier changes the location of the source or

encounters changes within the supply source, laboratory testing shall be performed on the new material to ensure compliance with specifications.

c. Field samples shall be secured in accordance with the current ASTM Methods of Sampling, Designation D75. Test samples shall be reduced from field samples by the means of ASTM C702.

d. Contractor shall use the attached Field Inspection Summary Report

e. If the source of subballast changes during subballast installation, additional certified test results (in accordance with the requirements included under Submittals and Quality Assurance) shall be provided to the Engineer for review and approval prior to the shipment of the subballast from the new source.

f. Supplier shall certify with billing that the subballast delivered is typical of the subballast which has been tested and approved by the Engineer.

g. Perform sampling and tests of the subballast material to determine compliance with specified requirements. Samples shall be initially taken from the supplier's source (quarry). Additional samples may be taken from the site at the direction of the Engineer.

3. Subballast shall conform to the following gradation:

Subballast	
Sieve Size	Percent Passing by Weight
1 Inch	100
3/8 Inch	50 to 85
No. 4	35 to 65
No. 10	25 to 50
No.40	15 to 25
No.200	4 to 10

Subballast shall consist of inert material that is hard, durable stone and coarse sand, free from loam and clay, surface coatings, and deleterious materials.

4. Production and Handling:

a. The subballast production facility shall be of such a design to permit production and/or blending without excessive working of the materials. The capacity of the production facility shall be adequate to efficiently produce the anticipated daily loadings providing sufficient stockpiles to facilitate loadings without any delays.

b. Blending, stockpiling and other production and handling operations shall be managed by the producer to keep subballast clean and minimize segregation of the finished product. Stockpiling operations shall minimize the breakage or excessive fall in stockpiling operations. The movement of wheeled or

tracked machines over stockpiled materials shall be limited.

5. Loading:
   a. Processed subballast shall be loaded only into rail cars or trucks which are in good order, tight enough to prevent leakage and waste of material, and clean and free from rubbish and other deleterious materials.
6. Inspection:
   a. MassDOT, or its representatives, reserve the right to make unscheduled visits to the supplier's facility during normal business hours for the following purposes:
      i. Observe sampling and testing procedures to assure compliance with the requirements of these specifications.
      ii. Obtain representative samples of the prepared material being produced and shipped.
      iii. Review plant inspection, methods, quality control procedures, equipment and review test results of both current and previous tests.
   b. The supplier shall provide MassDOT or its representative with such assistance, materials, and laboratory testing equipment as necessary to perform so called "on site production tests" consisting of site gradation and percent passing No. 200 sieve. Performance of these tests at the time of an unscheduled inspection visit is the right, but not the duty, of the inspector.
7. Acceptance/Rejection:
   a. To be accepted, subballast offered shall conform to this specification in all respects.
   b. Subballast is also subject to inspection at delivery and is at the supplier's risk until acceptance. Subballast rejected for non-compliance with this specification will be picked up, loaded, and transported off-site at the supplier's expense.

EXECUTION

GENERAL

1. Except as otherwise indicated in the Construction Documents, trackwork shall be completed and restored within the service outage times coordinated with the Housatonic Railroad as specified previously.
2. Trackwork shall be constructed to match existing line and existing profile except as indicated otherwise on the Contract Drawings and in these Special Provisions.
3. Contractor shall install track in accordance with current American Railway Engineering and Maintenance of Way Association, Manual for Railway Engineering and Portfolio of Trackwork Plans, MassDOT MW-1 including all Appendices, and these special provisions.

HANDLING AND STORAGE

1. Contractor shall be responsible for loading and transporting Owner and Railroad supplied products and materials from delivery and storage locations to the installation sites.

DEMOLITION

1. Contractor shall verify that utilities have been disconnected and capped before starting demolition operations.
2. Contractor shall protect any existing utilities, culverts, signal system equipment, mile posts, fences, and any other items not part of the demolition along the ROW. Should demolition activities damage any existing item, it shall be repaired or replaced immediately at no cost to the project.
3. Contractor shall protect any adjacent tracks and walkways not part of demolition during demolition operations. Contractor shall take care to not undermine or structurally impact any adjacent tracks and will be responsible for any damage that occurs to adjacent tracks during demolition operations. Contractor shall repair any damage at no cost to the Project.
4. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from MassDOT and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction. Provide no less than 72 hours' notice of activities that may impact these facilities.
5. Remove rail and OTM and save for use in reconstructing track in areas designated for Track Reconstruction as shown on the Contract Drawings. Demolish remaining existing track components.
6. All crossties, bridge timbers and miscellaneous wood materials not being salvaged shall be removed from the property and disposed of by ITEM 115.1 DEMOLITION OF BRIDGE NO.77.04 and in ITEM 115.2 DEMOLITION OF BRIDGE NO.79.81
    a. All existing crossties and bridge timber to be removed from the property shall become the property of the Contractor, removed from the ROW and disposed of at an approved facility.
    b. The Contractor shall provide the Engineer with a copy of a certified weight slip for each quantity shipped, unloaded, and properly disposed of at the licensed facility.
7. Remove existing ballast to the depth required to provide for installation of new ballast mat as indicated on the Contract Drawings.
8. Use methods required to complete the Work within limitations of governing regulations and as follows:
    c. In the event torch cutting is approved by the Engineer, do not use cutting torches until work area is cleared of flammable materials. Maintain portable

fire-suppression devices during flame-cutting operations.

   d. In the event torch cutting is approved by the Engineer, maintain fire watch during and for at least four hours after flame cutting operations.
   e. In the event torch cutting is approved by the Engineer, maintain adequate ventilation when using cutting torches.

9. Use of explosives is not permitted.
10. Do not burn demolished materials on site.
11. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.
12. On-site storage or sale of removed items or materials is not permitted.
13. With the exception of ferrous materials, all demolition waste and materials removed as part of this demolition shall become the property of the Contractor and shall be disposed of properly according to applicable local, State and Federal regulations, unless otherwise specified herein or by the Engineer.
14. All ferrous materials not designated for reuse shall be salvaged and shall remain the property of HRRC. All salvage materials shall be organized, transported to, and stockpiled at locations to be determined by the Operating Railroad.
15. Salvaged items, Contractor shall comply with the following:
    a. Clean salvaged items of dirt and demolition debris.
    b. Pack or crate items after cleaning. Identify contents of containers.
    c. Store items in a secure area until delivery to HRRC.
    d. Transport items to storage area designated by HRRC.
    e. Protect items from damage during transport and storage.
    f. Contractor shall follow HRRC's instructions for stockpiling, stacking and organizing salvaged materials to maintain proper organization and neatness.
16. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to the Operating Railroad or MassDOT that may be uncovered during demolition shall remain the property of MassDOT.
17. Remove demolition waste materials (excluding excess soil and ballast spoils) from the Project site and legally dispose of them in an EPA-approved landfill acceptable to authorities having jurisdiction.
    g. Do not allow demolished materials to accumulate on-site.
    h. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
18. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

REMOVAL OF EXISTING RAIL

1. Limits of rail removal shall be as indicated on the Contract Drawings.
2. Carefully remove the rail and OTM and transport to a storage area approved by the Engineer without damage. Materials damaged by the Contractor shall be replaced at no cost to MassDOT.
3. Protect rail and OTM from damage during the Work.

REMOVAL OF EXISTING CROSSTIES

1. The Engineer will mark existing ties to be salvaged.
2. Ties to be salvaged shall have spike holes plugged and be bundled at no extra cost to MassDOT using two straps to prevent movement and stored in such a way as to avoid damage. Any damage to these ties rendering them unusable will be the sole responsibility of the Contractor. The Contractor shall replace ties damaged at no cost to the project.
3. Salvaged ties shall be moved to a location within the right of way as directed by the Engineer.
4. Contractor shall remove existing tie plates and spikes from all existing timber cross ties and bridge timbers being removed.
5. Removed tie plates are to be collected by the Contractor and returned to a location designated by HRRC.
6. Removed spikes are to be collected by the Contractor and returned to a location designated by HRRC.

HANDLING AND DISPOSAL OF EXCAVATION SPOILS

1. Excess soil and ballast excavation spoils shall be transported and disposed of entirely within the railroad right of way in a manner to be approved by the Engineer and HRRC at specific locations as directed by HRRC. Disposal areas may be located up to 10 miles from the excavation areas.
2. Contractor shall load excavation spoils directly into air side dump cars, high rail swivel dumps or equivalent as approved by the Engineer. Stockpiling of excavation spoils is not allowed.
3. Contractor is responsible for providing, maintaining, and operating all rail mounted equipment.
4. HRRC will provide and operate locomotives needed to move air side dump cars.
5. Contactor is responsible for unloading spoils at the disposal areas and for dispersing and evenly spreading the materials at the disposal sites as directed by the Engineer.
6. Contractor is responsible for all scheduling and coordination with HRRC for transportation of spoils to the disposal areas. MassDOT is not responsible for delays

or any additional costs associated with transportation of spoils, all costs shall be the responsibility of the Contractor.

PLACING BALLAST MAT

1. Ballast mat shall be installed within the area of new timber tie installation as show on the Contract Drawings.
2. Existing ballast shall be removed to a minimum depth of 9” below the proposed bottom of tie elevation.
3. Where soft places are located they shall be undercut to a suitable depth, no less than 6 inches, and backfilled with granular aggregate as directed by the Engineer.
4. Prior to placement of ballast mat all trash and debris shall be removed from subgrade. Subgrade shall be clear and void of tire ruts, large stone or other deleterious objects before placement of ballast mat. Subgrade shall be freely drained and compacted to the required density before placement of ballast mat.
5. Approach Ballast Mat shall be installed in accordance with the manufacturer’s instructions and requirements. Approach Ballast mat shall be installed within the areas shown on the Contract Drawings.
6. Bridge Deck Ballast Mat shall be installed in accordance with the manufacturer’s instructions and requirements. Bridge Deck Ballast Mat shall be installed within the areas shown on the Contract Drawings. The bottom layer of the Bridge Deck Ballast Mat shall be extended up to the top of the inside sidewalls of the bridge deck structure.
7. Geotextile protection layer shall be installed on top of the ballast mat installation in accordance with the manufacturer’s requirements.
8. Ballast mat and geotextile shall not be driven over prior to placement of ballast.

SUBBALLAST

1. Prior to placement of subballast backfill all trash and debris shall be removed from subgrade. Subgrade shall be clear and void of tire ruts, large stone or other deleterious objects before placement of subballast. Subgrade shall be freely drained and compacted to the required density before placement of subballast.
2. Apply subballast course over the prepared subgrade or subbase and compact as directed by the Engineer.
3. Where soft places are located they shall be undercut to a suitable depth, no less than 6 inches, and backfilled with granular aggregate as directed by the Engineer.
4. Deliver aggregate for subballast as uniform mixture and spread in layers without segregation.
5. Place subballast material with sufficient moisture to allow compaction to specified maximum density.
6. Compaction shall be accomplished with one or more of the following:

a. Dynamic Compactor. The compactor shall be a vibratory roller or vibratory pad-type compactor capable of operating at the optimum frequency of vibration required for the size and type of compactor used and for the type of material being compacted. Vibratory pad-type compactors shall be used only when access with a vibratory roller is not practical. Vibratory rollers shall be equipped with a readily visible instruction plate containing the manufacturer's recommended operating frequency, amplitude and roller speed. A calibrated vibrating reed tachometer shall be provided with each roller to permit a mechanical check of the roller vibration control system.

7. Subballast course shall be minimum uniform thickness, after compaction, of dimensions indicated on the Contract Drawings or in the special provisions. Where not indicated, compacted thickness shall be a minimum of 4 inches.
8. Compaction of each layer shall continue until the material meets 95% dry density compaction. The in-place dry density of each compacted layer will be determined in accordance with AASHTO T 191.
9. Thickness of finished subballast course shall not vary more than 1 inch from the indicated thickness at any point. Reshape or rework, water, and recompact subballast to achieve compliance with specified requirements which do not conform to this requirement.
10. The surface of the finished subballast course at any point shall not vary more than +1” above or 0” below the indicated grade.
11. The Contractor shall obtain a test lab approved by the Engineer to perform tests in accordance with AASHTO T 191 and ASTM D2922 to determine compliance with specified requirements for density and compaction of subballast, and with ASTM D3017 to determine moisture content of the installed subballast.

PLACING INITIAL LAYERS OF BALLAST

1. Check grade lines and cross section prior to placing ballast.
2. Clean trackbed area of debris and standing water prior to placing ballast.
3. Care shall be taken to not damage the ballast mat installation.
4. Distribute and compact four inch layers (maximum) of ballast uniformly and as required to achieve required ballast depth prior to tie distribution.
5. Deliver ballast at a rate no faster than can be satisfactorily incorporated into the work, maintaining a proper interval of operations, and at such times as to permit proper inspection by the Engineer.
6. To extent practicable, unload ballast in position for use with a minimum of redistribution and dressing.
7. Self-spreading vehicles may be used as approved by the Engineer. When stone is initially spread by self-spreading vehicle a power grader may be used to assist spreading operations.
8. Shape ballast to a true section conforming to the ballast section shown on Standard Plans and Contract Drawings.

9. Thoroughly compact each ballast layer until stones are firmly interlocked and surface is true and unyielding. Compact each lift with not less than four passes of a roller or a vibratory compactor subject to the following requirements:
    a. Compact by rolling using either a self-propelled, three-wheel, or two axle roller of such weight that will provide compression under the rear wheels of not less than 350 pounds per linear inch of tread; or using a two or three-wheel tandem roller having a weight per inch of drive roll of not less than 350 pounds, and every part of the surface receiving compression from the drive wheels.
    b. Compact by vibration using vibratory compactors of either the roller or pad type. Dynamic force for either type shall not be less than 20,000 pounds and the frequency range shall be 1100 to 1500 vpm. Use machines equipped with a governor which can be set and locked to control rate of impulse. Provide a tachometer or other suitable device for accurately checking the frequency of vibration during the compacting operation.
10. Top surface of initial layers of ballast shall be smooth, flat and uniformly compacted prior to distributing ties.

DISTRIBUTING AND SPACING TIES

1. Carefully distribute and properly space all ties on initial layer of ballast. Space ties center to center as follows:
    a. 18 inches, unless otherwise noted.
2. Place timber ties so that heartwood is down. Place all ties so that the bottom surface of the tie shall have full bearing against the initial layer of ballast.
3. Handle treated timber ties in a manner to avoid breaking and bruising. Do not throw ties from cars or trucks onto rails or rocks.
4. Place all ties normal to center line of track unless shown otherwise on Contract Drawings.
5. Properly space and align all ties prior to rail installation.
6. In placing or spacing treated ties, handle only with tongs or suitable devices. Do not use bars, chisels, forks, mauls, picks, punches, shovels, or sledges for moving ties or placing them in position beneath rails.
7. Avoid unnecessary handling, redistribution, and reloading of all ties. To extent practical, distribute ties in proper position for use without further handling.
8. Remove any tie damaged as result of improper handling by the Contractor and rejected by the Engineer and replace with undamaged ties at no additional cost to MassDOT.

RE-INSTALLATION OF RAIL

1. Rail shall be installed in accordance with MassDOT MW-1 requirements for jointed

rail.

2. The distance between jointed rail ends shall be adjusted according to the temperature at which the rails are laid as per MassDOT MW-1.
3. Expansion shims shall be used to set rail end openings. The opening between the ends of rails for different rail temperatures for 39' rails shall be as follows:

Rail Temperature (F)	Rail End Opening (39' Rails)
Below 6°	5/16"
6° to 25°	1/4"
26° to 45°	3/16"
46° to 65°	1/8"
66° to 85°	1/16"
Over 85°	None

4. A standard rail thermometer shall be used to determine the rail temperature. The thermometer shall be laid close to the web on the side of the rail base, which is shaded from the sun's rays in advance of the laying operation and left there long enough to accurately record the temperature.
5. The supervisory employee in charge shall see that rail temperature is checked frequently and that proper rail expansion shims are used.
6. The Contractor shall provide a record of all rail temperatures and the required expansion shims used for review and approval by the Engineer.
7. In general, rails laid out-of-face in track panel rehabilitation and at rail replacement locations shall be placed so that the joints of one line of rails shall be opposite third point of rails in the other line.
8. Short rails less than 33' long shall not be used in track unless approved by the Engineer and shall be shown on the Contractor's steel plan.
9. Every effort shall be made by the contractor to utilize existing joint location.
10. Rail shall be anchored in accordance with MassDOT MW-1 and the following:
    a. A minimum of 40 anchors for a 78' rail and be boxed on 20 ties.
    b. A minimum of 16 anchors for a 39' rail and be boxed on 8 ties.
    c. A minimum of 10 anchors per 33' rail and be boxed on 5 ties.

TIE PLATES

1. Distribute tie plates prior to the timber crosstie installation process. The Contractor shall sign and account for any and all tie plates drawn from inventory if needed.
2. Timber crossties shall have tie plates installed under each rail.
3. Prior to installation of tie plates, clean contact surfaces to allow proper bearing of tie plate on the tie and rail on the tie plate.
4. Locate tie plates on 8 feet 6 inch ties so that the line side of tie is 18 1/2 inches from outer edge of base of rail. Tie plate shall be centered on the crosstie under rail.

5. Locate tie plates on longitudinal centerline of each tie and place square to centerline of rail so that field side of plate bears fully against rail base. Place plate with the downward cant toward center of track.
6. Secure rail on line end of ties at proper location before securing opposite rail.
7. Use line rail as reference in securing opposite rail to proper gauge. Line rail is the east side rail.

TRACK GAUGE

1. Track gauge shall be 56-1/2".

SPIKING

1. Each newly installed crosstie shall be spiked with one rail hold down spike on both the field side and gauge side of each plate (diagonally across). The Contractor shall ensure that the minimum specified number of spikes are installed on all ties in curves and throughout the entire project.
2. Start and install spikes vertically and square with rail. Install spikes straight/plumb.
3. Straightening spikes will not be permitted.
4. Avoid removal of spikes once driven. When necessary, pull spikes and plug hole using liquid plugging compound.
5. Under no circumstances shall gauge be adjusted by striking lags, spikes, or plate edge after it is fixed to tie.
6. Seat rail properly between tie plate shoulders on debris free plate with field side base of rail tight against field side plate shoulder.

LIQUID PLUGGING COMPOUND

1. The Contractor shall use a MassDOT approved chemical formulation for plugging crossties designated for salvage. Such compound shall have the equivalent or greater characteristics of the Willamette Valley Company SPIKEFAST® ES-50 RM formula.
2. Plugging compound shall be applied in a manner that is consistent with the chemical manufacturer's instructions. Spike holes shall be filled in completely with the approved plugging compound. Furnishing and installing liquid plugging compound for all work in this contact shall be incidental to installation of the rail.

<u>METHOD OF MEASUREMENT AND BASIS OF PAYMENT</u>

The Contractor shall provide all necessary labor, equipment and materials to be incorporated into the work as indicated on the Contract Drawings and in these Special Provisions.

Work under ITEM 492.11.1 TRACK RECONSTRUCTION shall be measured and paid at the contract unit price per TRACK FOOT under ITEM 492.11.1 TRACK RECONSTRUCTION

Temporary trackwork construction that may be required to complete the work, including but not limited to, temporary trackwork construction in support of bridge demolition, pile driving, sheet pile installation, bridge substructure and superstructure construction, approach slab construction, and temporary trackwork required to maintain HRRC train operations outside of authorized work windows, shall not be measured or paid for separately but shall be considered incidental to the work which it applies.

Handling and disposal of excavation spoils under ITEM 492.11.2 HANDLING AND DISPOSAL OF EXCAVATION SPOILS shall not be measured or paid separately, but shall be included in the contract unit price per TRACK FOOT under ITEM 492.11.1 TRACK RECONSTRUCTION.

ITEM 492.12 **TRACK UNDERDRAIN** **LF**

GENERAL

This section specifies furnishing and installing track underdrains.

SUBMITTALS

1. Submit a prepared construction sequence for installation of underdrains.
2. Submit the name and contact information for the pipe material supplier and the manufacturer's catalog cuts, material specifications and installation recommendations.

PRODUCTS

PERFORATED HIGH DENSITY POLYETHYLENE (HDPE) PIPE

1. Perforated high density polyethylene pipe and fittings for use as underdrain pipe shall be corrugated profile-wall pipe with a smooth interior wall. HDPE underdrain pipe shall meet the requirements of AASHTO M294 and ASTM F2306. Virgin material for pipe and fitting production shall be high-density polyethylene conforming with the minimum requirements of ASTM D3350, except that carbon black content should not exceed 4%.
2. Pipe joints shall comply with the requirements of AASHTO M294 and soil tight requirements of ASTM F2306. Pipe joints shall be watertight meeting the requirements of ASTM D3212. The joint gaskets shall comply with ASTM F477.
3. Fitting connections shall be with a bell and spigot connection utilizing a welded bell and valley gasket. The joint shall meet the watertight requirements of ASTM D3212, and gaskets shall meet the requirements of ASTM F477.
4. Perforations shall be Class 2 type, circular.

NON WOVEN GEOTEXTILE FOR RAILROAD DRAINAGE APPLICATIONS

1. Provide non woven geotextile for railroad drainage applications in accordance with ITEM 492.14 GEOTEXTILE MATERIALS.

UNDERDRAIN STONE

1. Underdrain stone shall be narrowly graded mixture of washed crushed stone; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.

EXECUTION

1. Underdrain trench shall conform to the dimensions shown on the Contract Drawings.
2. Place drainage geotextile around perimeter of underdrain trench. Place underdrain stone on drainage geotextile to support the underdrain pipe.
3. Install underdrain pipe in accordance with the manufacturer’s recommendations.
4. Encase underdrain pipe in stone as indicated on the Contract Drawings. Place stone in maximum 6 inch lifts and compact. Stone shall be thoroughly compacted to provide support for the pipe and to prevent settlement of the track surface above the trench.
5. Overlap subsurface drainage geotextile a minimum of 12” on top of the underdrain trench and a minimum of 12” at all other locations where the drainage geotextile overlaps.
6. Slope underdrains as indicated on the Contract Drawings.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The Contractor shall provide all necessary labor, equipment and materials to be incorporated into the work as indicated on the Contract Drawings and in these Special Provisions.

Work under ITEM 492.12 TRACK UNDERDRAIN shall be measured and paid at the contract unit price per LINEAR FOOT under ITEM 492.12 TRACK UNDERDRAIN.

ITEM 492.14 **GEOTEXTILE MATERIALS** **N/A**

GENERAL

This section specifies furnishing and installing geotextile materials for ballast mat protection and for railroad drainage purposes.

SUBMITTALS

1. Submit a prepared construction sequence for all geotextile materials installation.

2. Submit the name and contact information for the material supplier and the manufacturer's catalog cuts and material specifications.

PRODUCTS

NON WOVEN GEOTEXTILE FOR BALLAST MAT PROTECTION

1. Geotextile shall meet the requirements of AREMA Chapter 1, Section 10.1 "Geotextile and Geocomposite Specifications for Railroad Separation/Stabilization Applications".

2. Fibers used in the manufacture of the geotextile, and the thread used in joining the geotextile by sewing, shall consist of long-chain synthetic polymers, composed of at least 95 percent by weight of polyolefins or polyesters. Geotextile shall be a nonwoven fabric formed into a stable network such that the filaments or fibers retain their dimensional strength relative to each other.

3. The geotextile shall be inert to commonly encountered chemicals, hydrocarbons, and mildew. The geotextile shall be resistant to ultraviolet light, insects, and rodents. The geotextile shall be tinted or otherwise treated to prevent the occurrence of snow blindness of handling personnel.

4. The geotextile shall meet the property values for Regular Weight 10-12 Oz/SY stipulated in AREMA Table1-10-2, Chapter 1, Section 10.1.

NON WOVEN GEOTEXTILE FOR RAILROAD TRACKBED STABILIZATION

Not Used

NON WOVEN GEOTEXTILE FOR RAILROAD DRAINAGE APPLICATIONS

1. Geotextile shall meet the requirements of AREMA Chapter 1, Section 10.2 "Geotextile Specifications for Railroad Drainage Applications".

2. Fibers used in the manufacture of the geotextile, and the thread used in joining geotextile by sewing, shall consist of long-chain synthetic polymers, composed of

at least 95 percent by weight of polyolefins or polyesters. The geotextile shall be a nonwoven fabric formed into a stable network such that the filaments or fibers retain their dimensional strength relative to each other.

3. The geotextile shall be inert to commonly encountered chemicals, hydrocarbons, and mildew. The geotextile shall be resistant to ultraviolet light, rot, insects, or rodents.

4. The geotextile shall conform to the properties for Class A geotextile found in Table1-10-7, “Geotextile Survivability Properties for Drainage Geotextiles”, and Table1-10-8, “Geotextile Filtration Properties for Drainage Applications” found in AREMA Chapter 1, Section 10.2 “Geotextile Specifications for Railroad Drainage Applications”.

EXECUTION

1. The geotextile materials shall be installed as shown on the contract drawings and as described in this Special Provision.

2. Drainage Application geotextile shall be laid to encapsulate all underdrain trenches as shown on the Contract Drawings. The geotextile shall be installed as shown in the Contract Drawings with a minimum 12” overlap at the top closing joints of the filter fabric.

3. All geotextile shall be installed in accordance with the manufacturers requirements and recommendations.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The Contractor shall provide all necessary labor, equipment and materials to be incorporated into the work as indicated on the Contract Drawings and in these Special Provisions.

Separate Measurement and Payment will not be made for the work of this Special Provision complete in place. All costs shall be included in ITEM 492.11.1 TRACK RECONSTRUCTION. All preparation and incidental work necessary to accomplish the installation will be considered incidental to ITEM 492.11.1 TRACK RECONSTRUCTION and will not be meassured or paid seperately.

ITEM 493.1 MISCELLANEOUS WORK AS DIRECTED BY THE ENGINEER ALLOWANCE

GENERAL

This section specifies additional miscellaneous work to be performed as directed by the Engineer. No work shall be performed that is not within the scope of this Project and has not been explicitly directed by the Engineer.

SUBMITTALS

Prior to commencement of any directed work, Contractor shall submit procedures, tools and machinery, materials, and a description of the work. The Engineer shall also review and sign the document prior to submittal to MassDOT.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Payment under this item will be made at the contract unit bid price per ALLOWANCE. All labor and materials required to complete this work will be considered incidental to this section. No additional payment over the contract Allowance price will be made for any work that does not meet this section.

ITEM 698.4 GEOTEXTILE FABRIC FOR PERMANENT EROSION CONTROL SQUARE YARD

The work under this Item shall consist of furnishing and installing geotextile fabric below riprap embankments as shown on the Plans or as required by the Engineer.

The geotextile fabric shall conform to the requirements of M9.50.0, and AASHTO M 288 for the intended application and must be on the MassDOT QCML. Construction and installation shall be in accordance with the following. Atmospheric exposure of the geotextile fabric to the elements following lay down shall be a maximum of 14 days.

For seams that are sewn in the field, the Contractor shall provide at least a six-foot length of sample sewn seam for the approval of the Engineer before the geotextile fabric is installed. The seams sewn for sampling shall be sewn using the same type of equipment and procedures as will be used for the production seams. If seams are sewn in both the machine and cross machine direction, samples of seams for both directions shall be provided. The seam assembly description shall be submitted by the Contractor along with the seam samples. This description shall include the seam type, stitch type, sewing thread, and stitch density.

Geotextile shall be placed in intimate contact with soils without wrinkles or folds, and shall be anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlaying materials will not excessively stretch or tear it. Adjacent geotextile sheets shall be joined by either sewing or overlapping. At roll ends, overlapped seams shall overlap a minimum of 12 inches, except when placed under water, where they shall overlap a minimum of 3 feet. Adjacent rolls shall overlap a minimum of 12 inches.

Care shall be taken during installation to avoid damage to the geotextile as a result of the installation process. Should the geotextile be damaged, a geotextile patch shall be placed over the damaged area extending a minimum of 3 feet beyond the limits of the damage.

The Riprap placement shall begin at the toe of slope and proceed up the slope. Placement shall take place so as to avoid stretching and subsequent tearing of the geotextile. Stones shall not be dropped from a height exceeding 3 feet.

Field monitoring shall be performed to verify that the riprap placement does not damage the geotextile. Any geotextile damaged during backfill placement shall be replaced as required by the Engineer, at the Contractor’s expense.

METHOD OF MEASUREMENT

Geotextile Fabric for Permanent Erosion Control will be measured for payment by the Square Yard, complete in place.

BASIS OF PAYMENT

Geotextile Fabric for Permanent Erosion Control will be paid for at the Contract unit Price per Square Yard, which price shall include all labor, materials, equipment and incidental costs required to complete the work. Overlaps and fold-overs are considered incidental to the unit price and shall not be measured separately for cost.

ITEM 755.35 INLAND WETLAND REPLICATION AREA LUMP SUM

The work under this item shall conform to the relevant provisions of Sections 120, 770, 771 of the Standard Specifications and the following:

Work under this item shall include furnishing material and the construction and maintenance of inland wetland replication areas as shown on the drawings and as required by the Engineer. Inland Wetland Replication Area shall hereafter be referred to as Replication Area. All work shall be in coordination with an approved Wetland Specialist provided by MassDOT Rail and Transit.

Wetland Restoration work shall be as specified and compensated under that item.

The Replication Area shall be constructed prior to wetland impacts unless otherwise approved by the Engineer, specified herein, or specified in permit conditions and approvals. Construction schedule shall be appropriate to planting and seeding season (see below). Changes to this schedule will require written approval from the Engineer.

DESCRIPTION OF WORK

Construction of the Replication Area shall be completed as shown on the drawings:

Area = ***1,150*** sf.

Replication Area shall be constructed to meet the requirements of all associated permits and certifications, including relevant performance standards of the Massachusetts Wetlands Protection Act (MGL C. 131, s40), Section 401 Water Quality Certification, and Section 404, U.S. Army Corps of Engineers Permit.

The Contractor is responsible for protection and preservation of natural areas adjacent to the Replication Area both within and outside the project limits and for the duration of the Contract; including but not limited to damage to soils or vegetation due to erosion, sedimentation, compaction, trampling, vehicles, storage of materials, or other negligence shall be repaired to the satisfaction of the Engineer and at the Contractor’s expense.

The Wetland Specialist overseeing the Wetland Replication construction work shall not be from the same company as that which is performing planting, seeding, or participating in any aspect of the Wetland Replication construction.

SUBMITTALS - DOCUMENTS

Request for Conditional Acceptance: As specified below, a letter requesting Conditional Acceptance of the work and the site conditions shall be submitted to the Engineer.

Request for Certificate of Compliance (Partial or Full): As specified below, shall be submitted to the Engineer for distribution to appropriate regulatory agencies.

Request for Final Acceptance: As specified below, a letter requesting Final Acceptance of the work and the site conditions shall be submitted to the Engineer.

submittals - MATERIAL

Soil and Amendments

No soil, compost, or other soil amendment imported to the work site shall contain seeds, roots, stems, or other viable parts of invasive plants or other noxious plants.

At least sixty (60) days prior to installation and prior to ordering, the Contractor shall submit for approval sources of soil, compost, and amendments. Submittal shall include the supplier and location of the source. Off-site sources shall be identified and available for inspection by the Wetland Specialist prior to transport of material to the site to verify that they are likely to be free of invasive plant species, including all viable plant parts.

Samples of tested and approved wetland soil and soil amendments for soil texture, organic carbon content or other routine soil analysis parameters (e.g., pH, Cation Exchange Capacity, Percent Base Saturation) and Soil Organic Matter Analysis will be required if requested by the Engineer. The grab samples shall be collected by the Contractor or Wetland Specialist from multiple representative locations in the wetland topsoil mix following the “Umass Soil and Plant Tissue Testing Laboratory Sampling and Collection Protocols” (or equivalent certification paperwork provided by the soil supplier). The lab analysis shall be provided to the Engineer along with written certification from the Contractor or Wetland Specialist that the wetland topsoil was collected per the referenced protocol and meets the desired specification. The analysis and written certification of same shall be provided to the Engineer prior to placing the wetland topsoil in the Replication Area.

Seed Mix

Certificate of Materials from the supplier shall be submitted 30 days prior to seeding and must be approved prior to ordering materials. Seed species listed on the certificate shall include ecotype region (i.e., *Asclepias incarnata*, PA Ecotype).

Seed tag from the bag of seed used shall be submitted to the Engineer at the time of seeding. Seed tag shall include ecotype region and species, guaranteed percentages of purity, weed content and germination of the seed, and the net weight. Seed tag shall match the Certificate of Materials, include the name of the supplier, and date material was sent.

Bill of lading or notarized Certificate of Compliance from the Supplier serving as proof of purchase shall be submitted if requested by the Engineer. Document shall include date of sale, quantity, lot number, and address of Supplier. This shall match the seed tag. Notary shall not work for either the contractor or seed supplier.

See attached Seed Mix Specification 765.553

Plant Certification

Plant Certification shall be per the applicable requirements of Subsection 771, PLANTING TREES, SHRUBS AND GROUNDCOVER, of the Standard Specifications. The nursery source shall certify the provenance or origin of all plants.

Other Material: Submittals shall be per the respective item.

MATERIALS

Sediment Control Barrier and Erosion Prevention Measures

Sediment control barriers shall be per Item 767.121.

Erosion prevention measures for disturbed areas adjacent to the Replication Area shall include but not necessarily be limited to compost blankets, jute mesh, seeding, and/or combinations thereof as approved by the Engineer.

Sediment controls and erosion prevention devices and measures shall be compensated under the respective items.

Coconut/ Coir Fiber Log

Coir Log shall be biodegradable coir fiber cylindrical bundles with a diameter of 12 inches with the length of each log module at 20 feet or 10 feet as needed to meet the layout requirements as indicated on the Contract Documents. Inner Core shall be 100% unsorted, well-cleaned, coir fiber uniformly distributed along the length of the log. The stuffed density of the coir fiber shall be a minimum of 9 lbs/cubic foot. Outer netting shall be constructed from a minimum 3-ply high strength coir bristle twine or yarn. The netting shall have 2 inch x 2inch rhombic openings with hand-knotted junctions. The average

breaking strength of the coir twine or yarn shall be a minimum of 90 lbs. Minimum diameter of the coir twine or yarn shall be 3/8 inch. Production tolerance for all the above parameters shall not exceed plus or minus 10%.

Wetland Soil

Soil appropriate for the Replication Area may be either hydric soil excavated from the impacted wetland, a manufactured mix of compost and on-site borrow, or a combination thereof, as approved by the Engineer.

Hydric soil from the impacted wetland area may be spread on the surface of the constructed Replication Area as an inoculant or can be placed in a bulk fashion in a roughly 1:1 ratio of area and depth. Soil shall be handled such that the original soil structure is preserved and shall not be compacted, screened, or otherwise processed.

Hydric soil from the impacted wetland that is infested with invasive plant species identified on the Massachusetts Invasive Plant Advisory Group (MIPAG) shall not be used in the Replication Area unless approved by the Wetland Specialist and Engineer. To the extent possible, infested soil shall be disposed of within the project limits in an upland area outside of regulated areas and as approved by the Invasive Plant Management Strategy item (if in the contract) or by the Engineer.

A manufactured mix suitable for wetlands shall consist of on-site borrow from the proposed Replication Area (if approved by the Wetland Specialist and Engineer) thoroughly mixed with compost to achieve a target organic carbon content of 10-12% (up to 21% percent organic matter) by dry weight. The organic material used for mixing shall be well or partially decomposed. Clean leaf compost is the preferred soil amendment to achieve these standards though other materials may be used if approved by the Wetland Specialist and Engineer. Note that "clean" refers both to a negligible amount (<1%) of physical contaminants such as plastic and to the lack of chemical contaminants that might pose a hazard to plants or animals. Off-site borrow may be used for mixing if approved in advance by the Engineer.

No soil or soil amendment shall be brought on site without approval of the material source by the Wetland Specialist and the Engineer. Soils used in the replacement area shall be free of rocks greater than 4 inches in diameter.

Plants

Plant material shall conform to the applicable requirements of Section 771, PLANTING TREES, SHRUBS AND GROUNDCOVER, of the latest edition of the Standard Specifications and as amended below.

Plants shall be native species, not cultivars. To the extent possible, plants shall originate from the applicable EPA Level III Ecoregion.

Plant species and sizes to be included in the Replication Area shall be as specified on the plans.

Requests for substitutions shall be submitted in writing to the Engineer for review by the Wetland Specialist, MassDOT Landscape Architect, and, if required, the relevant regulatory agency at least thirty (30) days prior to planting. All proposed substitutes shall be in conformance with the requirements herein and suitable for the site conditions.

Transplanting and plant material collected from the wild is prohibited unless approved in writing by the Engineer. Plants shall be selected from certified nurseries that have been inspected by state and/or federal agencies.

Herbaceous Plant Plug

Herbaceous Plant Plug shall be 2-inch deep size, fully rooted through a substrate of horticultural planting media in the nursery. Plant plug shall be healthy and well cared for, with no evidence of insects or diseases present. Insect-ridden or diseased plants shall be rejected. Plants shall have a deep green foliage and dense, compact growth.

Seed Mix

Seeding shall conform to the Standard Specifications Section M6, ROADSIDE DEVELOPMENT MATERIALS.

Mix 765.554 Wetland – Riparian Mix*

* or similar such as New England Wetmix (New England Wetland Plants) or Ernst Seeds PA New England Province FACW mix

	Botanical Name	Common Name	%PLS by Weight
Grass			
	Sorghastrum nutans NY Eco	Indiangrass NY Ecotype	14.00%
	Schizachyrium scoparium	Little Blue Stem	14.00%
	Elymus riparius	Riverbank Wild Rye	10.00%
	Elymus virginicus	Virginia Wild Rye	10.00%

Panicum clandestinum 'Tioga'	Deer Tongue 'Tioga'	9.00%
Andropogon gerardii NY Eco	Big Bluestem NY Eco	8.00%
Carex vulpinoidea	Fox Sedge	7.00%
Panicum virgatum	Switchgrass	3.00%
Juncus effusus	Soft Rush	2.00%
Agrostis perennans	Upland Bentgrass	2.00%
Scirpus atrovirens	Green Bulrush	1.00%
		80.00%
Herb/Forb		
Chamaecrista fasciculata	Partridge Pea	3.00%
Verbena hastata	Blue Vervain	3.00%
Asclepias incarnata	Swamp Milkweed	3.00%
Heliopsis helianthoides	Ox-Eye Sunflower	2.00%
Eupatorium perfoliatum	Boneset	2.00%
Aster umbellatus	Flat Topped White Aster	1.00%
Aster prenanthoides	Zig Zag Aster	1.00%
Aster puniceus	Aster – Swamp	1.00%
Aster novae-angliae	New England Aster	1.00%
Eupatorium maculatum	Joe-pye Weed	1.00%
Monarda fistulosa	Wild Bergamot	1.00%
Vernonia noveboracensis	New York Ironweed	1.00%
		20.00%
		100.00%

Seeding Rate:

Species ecotype shall be as native to New England region as possible. Apply this mix at 20 lbs PLS/acre.

Fertilizers shall not be used.

Water

The Contractor shall provide water and all equipment required at no extra cost. Water shall be suitable for irrigation and free from ingredients harmful to plants and wildlife. Water

from the adjacent water bodies or waterways shall not be utilized. It is the Contractor's responsibility to correct injury or damage due to the lack of water, too much water, or use of contaminated water.

Mulch/Compost Blanket for Seeding

Hydromulch shall be per the manufacturer’s recommendations and shall be wood fiber or straw mulch only. Mulch shall be incidental to seeding.

Compost Blanket may be used in lieu of mulch for seeding. Compost Blanket shall meet the material and submittal requirements of that Item and shall be applied as specified below. Compost Blanket shall be compensated under that item.

CONSTRUCTION METHODS & sequence

SITE PROTECTION MEASURES

Minimizing Damage

The Contractor shall plan and execute operations in a manner minimizing the amount of excavated and exposed fill or other foreign materials that could be washed or otherwise carried into Replication Area and nearby resource areas.

Construction of and access to the Replication Area shall minimize damage to existing vegetation and soils as specified herein. Damage to soils or vegetation shall be repaired to the satisfaction of the Engineer and at the Contractor’s expense. If required for soil remediation, tilling and the addition of compost shall be at the Contractor’s expense.

Wetland topsoil shall be deposited and graded in the Replication Area in a manner that minimizes travel and subsequent compaction of the subgrade to the extent practicable, including use of track mounted excavators as appropriate. Should soils be compacted, they shall be loosened by a method such as disking, spring-tooth harrowing and/or rototilling. The Contractor shall use boards, timber or composite mats, or other approved materials as necessary, to protect existing and/or new wetlands from compaction due to heavy foot traffic or if equipment is required to travel over wetland soil. All labor and materials required for protection and preservation of site shall be incidental to this item.

Stockpiling of Soil

Stockpiling of soil, including hydric soil for replication, shall be at least 100 feet from the edge of the bordering and isolated vegetated wetlands and 200 feet from inland banks, unless approved otherwise by the Engineer. Stockpiled soils shall be securely stabilized and contained. Any areas of exposed soil or stockpiles within and adjacent to the Replication Area that will remain inactive for more than 7 calendar days shall be sown with a mix of rapid germinating annual grasses (e.g., annual rye) covered with a layer of straw mulch applied at a rate of 90 pounds per 1,000 square feet. As necessary, the mulch shall be anchored with a tacking coat (non-tar) applied by a hydro seeder or other method recommended by the Wetland Specialist in consultation with the Engineer. In the event that there is excess borrow, it shall be disposed of under Excavation, Item 120.1.

Sediment Barriers

Placement: Sediment barriers shall be installed along the downslope perimeter of the Replication Area beginning and ending in the surrounding upland so that no excavated material or disturbed soil can enter adjacent wetlands or waters. Where construction work is immediately upgradient of the wetland, barriers shall be located so as to protect the Replication Area until slopes are stabilized. Sediment barriers shall be in place and approved by the Engineer prior to excavation work. No work shall take place outside the barriers.

Maintenance: The Contractor shall ensure that all sediment barriers function as intended and at all times per the specifications of those respective items.

Existing Trees to Remain

Tree protection shall be per the relevant specifications and as shown on the plans or as required by the Engineer. To protect root systems of existing trees to remain, the limits of the Replication Area may be adjusted, but, the total area of replication required by the permits shall not be reduced. Access route may be adjusted as required.

Coarse woody debris in the form of cut trees, stumps, logs, and brush shall be incorporated as shown on the plans or as directed by the Wetland Specialist or Landscape Architect. On site material shall be selected and marked by the Wetland Specialist, retained on the project site, and placed as specified below under Placement of Coarse Woody Debris.

All trees, stumps, or brush not specified to remain shall be removed and shall not be stockpiled in the wetland resource areas while awaiting disposal.

Work shall be coordinated with Clearing or Tree Removal Item and compensated under that Item.

PRE-WETLAND CONSTRUCTION SITE WALK

Delineating the Replication Area and Access Route. The Contractor shall stake out the Replication Area boundaries and the intended access route and set grade stakes for approval by the Wetland Specialist and Engineer. Following staking and demarcation of areas, the Engineer and Wetland Specialist shall approve or modify as necessary the limits of work, the access route, final location and configuration of replication, grade stake elevations, proposed location of sediment barriers, and review proposed construction methods.

As part of the delineation and approval process, the Wetland Specialist shall mark trees to be converted to snags, select course woody debris to be retained for re-use, and select rocks or other elements to be used for habitat features.

Invasive Plants: As part of the initial site walk, the wetland to be impacted and the proposed replication site shall be inspected for the presence of invasive plants. If invasive plants are found they shall be addressed as described herein under Invasive Plants.

Coconut/ Coir Log Installation

Large wood stakes shall be driven on both sides of the coir log, three feet on center. Insert stake through netting of the coir logs. The lengths of coir logs shall be placed in position adjacent to the row of stakes, between the bank and stakes.

Duckbill anchors shall be driven into the soil and then cinched tightly around the coir logs, 6-inches in from both ends of a typical 10foot long coir log section (provide two (2) per 10-foot log section). Install duckbill anchors per manufacturer's instructions.

The coir logs shall be laced together end-to-end with cord to create a continuous length. End-to-end lacing may be completed before or after placement on slope, to facilitate handling.

The upstream and downstream end of the coir logs shall be buried 2 to 4 feet laterally into the bank.

Excavation and fill work shall be completed as required on the bank above the coir log only after it is fully installed. Contractor shall shape bank according to Contract Documents and as required by the Engineer. The gap between the log and the bank shall be backfilled with loam as needed. Care shall be taken to disturb as little soil as possible

outside the work area, and to avoid damage to any existing trees and shrubs on or near the bank. All topsoil excavated from the project shall be stored on site and reapplied as a surface layer over any cut and fill work or blended for use as Wetland Topsoil.

The coconut / coir logs shall be installed then backfilled on the up-slope, then followed by the installation of the herbaceous plant plugs.

SOIL WORK

Final grades in the Replication Area shall meet the target elevations as shown on the Plans or as adjusted by the Wetland Specialist to achieve the desired hydrology and micro-habitat. If adjustments are required, a Request for Information (RFI) shall be submitted to the Engineer for approval. Adjustments shall be documented and included in the As-Built plans and other applicable required documents.

<u>Excavation & Grading</u>

When required by permits, the Wetland Specialist shall notify MADEP and the ACOE (as applicable) at least 72 hours prior to excavation.

Soil in the proposed wetland areas that must be removed for grades to conform to the proposed elevations shall be stripped and disposed of, or, if suitable for reuse, be stockpiled in an approved location. Stockpiled soils shall be kept wet and not allowed to dry out. Procedures for maintaining appropriate moisture levels shall be documented by the Wetland Specialist and provided to the Engineer and the Contractor.

Replication area shall be excavated as shown on the drawings. Where replication area is adjacent to existing reference wetland, finish grade of replication shall generally match existing grades and micro-topography, notwithstanding any deviations that are necessary to achieve the desired hydrology and habitat in the Replication Area.

Prior to placement of backfill, scarify subgrade to a depth of 4 to 6 inches.

Final grades in the Mitigation Area shall meet the target elevations as shown on the Plans or as adjusted by the Wetland Specialist. If adjustments are required, a Request for Information (RFI) shall be submitted to the Engineer for approval. Adjustments shall be documented and included in the As-Built plans and other applicable required documents.

<u>Placement of Wetland Soil</u>

Following excavation, scarification, and grading of sub-grade, and after the sub-grade elevations are approved by the Wetland Specialist, suitable soil previously removed or an evenly mixed organic/mineral soil created on-site shall be spread to the design depth and thickness over the proposed wetland area as shown on the plans and as directed by the Wetland Specialist.

Vehicles used to transport soil from offsite shall be washed or cleaned with air pressure to prevent exotic or invasive seeds or root fragments from contaminating the Replication Area.

Final Grading

The finished grade of the Replication Area shall be at an elevation that will provide an unrestricted hydrologic connection between the Replication Area and adjacent resource areas. The hydrologic connection should be in keeping with restoring the intended function of the replacement wetland relative to the impacted reference wetland. The Contractor shall verify that this elevation is not at a level that could negatively alter the hydrology of an adjacent wetland. Final elevations and grading of wetland soil shall be approved by the Wetland Specialist and the Engineer.

To avoid compaction once soil has been placed, no heavy equipment shall travel across placed soil and no work shall occur in wet or moist soil. Soil that is compacted due to construction activities shall be replaced with soil as specified herein and at the Contractor's expense.

RESTORING VEGETATION

Placement of Coarse Woody Material

If specified within this Contract or if directed by the Wetland Specialist or Landscape Architect during the initial site walk, woody debris shall be placed in the Replication Area and/or adjacent upland buffer. Material shall be placed as shown on the plans or as directed following placement of wetland soil and prior to application of compost and/or seed. Woody material shall cover a minimum of 5-10 percent of the Replication Area, depending on whether it is a meadow or woodland wetland and how much wood is available from construction clearing. Where trees are cut for construction purposes, logs of a minimum length of 8 feet must comprise a minimum of 50% of the woody material left on site. Brush shall be included along with logs and stumps as directed. Woody material shall be placed in a deliberate and naturalistic manner.

Planting

Following placement of wetland soil and approval of final grade and conditions, Replication Area shall be planted. Planting shall conform to SECTION 771 PLANTING TREES, SHRUBS AND GROUNDCOVER of the Division I Standard Specifications and as amended below.

Planting Season shall be May 15-June 15 and September 1-November 1 unless otherwise specified in applicable permit conditions.

Prior to planting, the Wetland Specialist shall approve the condition of the plant material and the method of installation and shall oversee the planting work. Replication Area shall be planted in the dry. Plants shall be placed according to the planting details and within the range of target elevations and at the direction of the Wetland Specialist. Unless otherwise noted on the Plans, final plant locations shall be determined on site and located with regard to expected hydrology, plant growth characteristics, habitat desired, and water protection.

Plant material shall be installed as soon as possible after delivery. Plants stored on-site prior to installation shall be stored in the shade and watered twice daily up until time of installation. Plants showing signs of stress or compromised health may be rejected by the Engineer or Wetland Specialist and shall be replaced at the Contractor's expense.

Plant material shall be furnished and installed as indicated including all labor, materials, plants, equipment, incidentals, re-setting of plants (frost heaves, etc), irrigation, re-planting and clean up. If previously approved species are not available at the time of planting, the Wetland Specialist may propose substitutions relative to species, size, and quantities for review and approval by the MassDOT Landscape Architect. Upon approval by MassDOT, substitutions shall be approved by the regulating authority, if and as necessary. Provisions shall be made for a growth warranty of at least two (2) calendar years from the date of Conditional Acceptance as described below or as required by permits.

<u>Seeding</u>

Following placement of wetland soil and planting, the Replication Area shall be seeded using one of the following methods:

- Broadcast by hand or with a hand-held spreader followed by application of straw mulch. If necessary, seed shall be lightly raked to insure good seed-to-soil contact.
- Hydro-seeded with hydro mulch per the Standard Specifications and per the manufacturer's directions.
- Hand broadcast seed with Compost Blanket pneumatically applied at the same time to ensure light cover of soil topdressing over seed.

If spring conditions are drier than usual, supplemental watering may be required. If sowing during the summer months, supplemental watering will likely be required until germination.

If required, seeding limits for different seed mixes shall be determined by the Wetland Specialist.

PLANT ESTABLISHMENT AND INVASIVE MANAGEMENT

Woody Plants shall be watered as necessary to maintain healthy establishment. Plants that fail by September 1 after spring planting or by May 15 after fall planting shall be replaced within the immediate or next planting period and at the Contractor's expense.

Seeding that fails to established according to the conditions of acceptance below shall be over-seeded as required by the Engineer. Washouts and channels shall be repaired and stabilized prior to overseeding. Excessive weed growth shall be pulled out by the roots or, with approval from the Engineer, cut prior to over-seeding. Soil repair and weed control are incidental to this item.

Plant Plugs shall be watered as necessary to maintain healthy establishment. Plugs that fail shall be replaced to maintain 50% or more of the original number planted in the coir logs. Plants replacements shall be at the Contractor's expense.

Invasive Plants: Corrective measures shall be taken to remove or treat invasive plant species in the Replication Areas. Invasive plants shall include those listed as invasive by Massachusetts Invasive Plant Advisory Group (MIPAG) and the US Army Corp of Engineer's New England District's Compensatory Mitigation Guidance

The strategy for chemical and/or manual removal shall be as directed by the Wetland Specialist, shall continue for the duration of the monitoring period, and shall be incidental to this item.

Conditional Acceptance of Work

Conditional Acceptance shall indicate approval of the wetland construction work and agreement that work has been done according to plan or modified as approved.

Upon completion of construction, the Contractor shall submit a Request for Conditional Acceptance that includes a brief narrative from the Wetland Specialist demonstrating that the wetland replication construction work was done according to plans (or how modified)

and meets required permit conditions. The narrative shall include, photo-documentation of pre-construction conditions as well as soil work, planting, and seeding. Seed tags shall be submitted as part of the Request for Conditional Acceptance.

Upon receipt of a Request for Conditional Acceptance, the Engineer, the Wetland Specialist, and regulatory representative (if required) shall assess the Replication Area and surrounding areas. At a minimum, the following conditions shall be included in the narrative and reviewed as part of the on-site assessment of whether:

- The final finished target elevations have been met and maintained relative to the approved plans and reference wetland. Areas that are too high or too low should be identified along with suggested corrective measures.
- Hydrology meets performance standards.
- Specified seed mix has been seeded. If inspected 30 or more days after seeding, seeded species in the wetland and adjacent upland shall show signs of good germination and healthy growth.
- Planted woody and herbaceous species meet specifications and are establishing well.
- Soils are stabilized and there is no sediment in the wetland and no channeling of slopes.
- There are no invasive plants visible in the replication area.

Upon approval that the work meets the above conditions, MassDOT will issue a letter of Conditional Acceptance. If the Wetland Replication work is not approved, MassDOT will issue a rejection letter requiring corrective actions. The Wetland Specialist shall recommend corrective actions. Work not approved shall be addressed by the Contractor at no extra cost.

Erosion of adjacent slopes or the flow of sediments into the wetland between Conditional and Final Acceptance shall be immediately addressed by the Contractor.

FINAL acceptance OF WORK

Following one full growing season, the Contractor shall submit a Request for Final Acceptance. Submittal shall include a brief narrative of conditions. Upon receiving the Request, the Engineer, Contractor, Wetland Specialist and regulatory representative (if required) shall assess the Replication Area. Final Acceptance will initiate the start of the Wetland Monitoring Period.

The following conditions shall be inspected and approved for acceptance and payment.

- Hydrology is functioning as intended.
- The desired seeded species are establishing well and cover at least 95 percent of the Replication Area, excluding areas of open water areas or planned bare soil.
- No sediments have entered the wetland.
- Adjacent slopes are stabilized with desirable vegetation.
- All planted woody species are living and establishing well.
- 50% or more of the planted plugs are living and establishing well.
- There are no visible invasive plants.
- Silt fence and non-biodegradable sediment barrier materials have been removed.

If the mitigation work does not meet the above condition and is not approved, MassDOT will issue a rejection letter requiring corrective action. The Wetland Specialist shall recommend corrective actions. Work not approved will be addressed by the Contractor at no extra cost.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Item 755.35 will be paid for at the Contract unit price per Lump Sum, which price shall include all labor, materials, equipment, submittals, maintenance, all required soil, site preparation, excavation and erosion control, grading, wetland seeding, planting, mulching, watering, registered surveyor, as-built plans, and all incidental costs necessary to complete the work as required.

Payment shall be as follows:

- 60% upon Conditional Acceptance.
- 20% after receipt and acceptance of Certificate of Compliance by the Engineer and once all permit construction requirements have been met and approved.
- 20% upon Final Acceptance.

ITEM 767.121 SEDIMENT CONTROL BARRIER FOOT

The work under this item shall conform to the relevant provisions of Subsections 670, 751 and 767 of the Standard Specifications and shall include the furnishing and placement of a sediment control barrier. Sediment control barrier shall be installed prior to disturbing upslope soil.

The purpose of the sediment control barrier is to slow runoff velocity and filter suspended sediments from storm water flow. Sediment barrier may be used to contain stockpile sediments, to break slope length, and to slow or prevent upgradient water or water off road surfaces from flowing into a work zone. Contractor shall be responsible for ensuring that barriers fulfill the intent of adequately controlling siltation and runoff.

Twelve-inch diameter (after installation) compost filter tubes with biodegradable natural fabric (i.e., cotton, jute, burlap) are intended to be the primary sedimentation control barrier. Photo-biodegradable fabric shall not be used.

For small areas of disturbance with minimal slope and slope length, the Engineer may approve the following sediment control methods:

- 12-inch compost filter tubes
- Straw bales which shall be trenched

No straw wattles may be used. Additional compost filter tubes (adding depth or height) shall be used at specific locations of concentrated flow such as at gully points, steep slopes, or identified failure points in the sediment capture line.

When required by permits, additional sediment barrier shall be stored on-site for emergency use and replacement for the duration of the contract.

Where shown on the plans or when required by permits, sedimentation fence shall be used in addition to compost filter tubes and straw bales and shall be compensated under that item.

Sediment control barriers shall be installed in the approximate location as shown on the plans and as required so that no excavated or disturbed soil can enter mitigation areas or adjacent wetlands or waterways. If necessary to accommodate field conditions and to maximize effectiveness, barrier locations may be shifted with approval from the Engineer. Barriers shall be in place prior to excavation work. No work shall take place outside the barriers.

MATERIALS AND CONSTRUCTION

Prior to initial placement of barriers, the Contractor and the Engineer shall review locations specified on the plans and adjust placement to ensure that the placement will provide maximum effectiveness.

Barriers shall be staked, trenched, and/or wedged as specified herein and according to the Manufacturer's instructions. Barriers shall be securely in contact with existing soil such that there is no flow beneath the barrier.

Compost Filter Tube

Compost material inside the filter tube shall meet M1.06.0, except for the following: no peat, manure or bio-solids shall be used; no kiln-dried wood or construction debris shall be allowed; material shall pass through a 2-inch sieve; and the C:N ratio shall be disregarded.

Outer tube fabric shall be made of 100% biodegradable materials (i.e., cotton, hemp or jute) and shall have a knitted mesh with openings that allow for sufficient water flow and effective sediment capture.

Tubes shall be tamped, but not trenched, to ensure good contact with soil. When reinforcement is necessary, tubes shall be stacked as shown on the detail plans.

See DEP approval and requirements for use of Compost Filter Tube in Document A00841.

Straw Bales

Straw bales shall be used if shown on the plans or when specified by Orders of Condition or other permit requirements.

Bales should be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another. All bales should be either wire-bound or string-tied. Straw bales should be installed so that bindings are oriented around the sides (rather than along the tops and bottoms) of the bales in order to prevent deterioration of the bindings.

The barrier should be entrenched and backfilled. A trench should be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil should be backfilled against the barrier. Backfill soil should conform to the ground level on the downhill side and should be built up to 4 inches against the uphill side of the barrier.

Each bale should be securely anchored by at least 2 stakes or re-bars driven through the bale. The first stake in each bale should be driven toward the previously laid bale to force the bales together. Stakes or re-bars should be driven deep enough into the ground to securely anchor the bales. For safety reasons, stakes should not extend above the bales but should be driven in flush with the top of the bale.

The gaps between the bales should be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from

a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.

When used in a swale, the barrier should be extended to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Sedimentation Fence

Materials and Installation shall be per Section 670.40 and 670.60 of the Standard Specifications and the following:

Sedimentation fence shall only be used if shown on the plans or when specified by Orders of Condition or other permit requirements.

When used with compost filter tubes, the tube shall be placed on a minimum of 8 inches of folded fabric on the upslope side of the fence. Fabric does not need to be trenched.

When used with straw bales, an 8-inch deep and 4-inch wide trench or V-trench shall be dug on the upslope side of the fence line. One foot of fabric shall be placed in the bottom of the trench followed by backfilling with compacted earth or gravel. Stakes shall be on the down slope side of the trench and shall be spaced such that the fence remains vertical and effective.

Width of fabric shall be sufficient to provide a 36-inch high barrier after fabric is folded or trenched. Sagging fabric will require additional staking or other anchoring.

MAINTENANCE

Maintenance of the sediment control barrier shall be per Section 670.60 of the Standard Specifications or per the Stormwater Pollution Prevention Plan (SWPPP), whichever is more restrictive.

The contractor shall inspect the sediment barrier in accordance with relevant permits. At a minimum, barriers shall be inspected at least once every 7 calendar days and after a rain event resulting in 0.25 inches or more of rainfall. Contractor shall be responsible for ensuring that an effective barrier is in place and working effectively for all phases of the Contract.

Barriers that decompose such that they no longer provide the function required shall be repaired or replaced as directed. If the resulting berm of compost within the fabric tube is sufficiently intact (despite fabric decay) and continues to provide effective water and sediment control, barrier does not necessarily require replacement.

DISMANTLING & REMOVING

Barriers shall be dismantled and/or removed, as required, when construction work is complete and upslope areas have been permanently stabilized and after receiving permission to do so from the Engineer.

Regardless of site context, nonbiodegradable material and components of the sediment barriers, including photo-biodegradable fabric, plastic netting, nylon twine, and sedimentation fence, shall be removed and disposed off-site by the Contractor.

For naturalized areas, biodegradable, natural fabric and material may be left in place to decompose on-site. In urban, residential, or other locations where aesthetics is a concern, the following shall apply:

- Compost filter tube fabric shall be cut and removed, and compost shall be raked to blend evenly (as would be done with a soil amendment or mulch). No more than a 2-inch depth shall be left on soil substrate.
- Straw bales shall be removed and disposed off-site by the Contractor. Areas of trenching shall be raked smooth and disturbed soils stabilized with a seed mix matching adjacent seeding or existing grasses (i.e., lawn or native grass mix).
- Sedimentation fence, stakes, and other debris shall be removed and disposed off-site. Site shall be restored to a neat and clean condition.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Item 767.121 will be measured and paid for at the contract unit price per foot of sediment control barrier which price shall include all labor, equipment, materials, maintenance, dismantling, removal, restoration of soil, and all incidental costs required to complete the work.

Sediment control barrier used for wetland mitigation area will be paid under Item 755.35 Inland Wetland Replication Area.

Barriers that have been driven over or otherwise damage by construction activities shall be repaired or replaced as directed by the Engineer at the Contractors expense.

ITEM 850.41 **RAILROAD SERVICES** **ALLOWANCE**

DESCRIPTION

Work under this item shall be performed by signal system personnel and railroad flaggers provided by the Housatonic Railroad (HRRC).

No work will be permitted by the Contractor without the HRRC flagger being present. Each workday will begin with the required Job Briefing which will be given by the HRRC flagger.

The Contractor shall be responsible for scheduling and coordinating their work with HRRC and retain the flagger service from HRRC. MassDOT is not responsible for delays or any additional costs associated with scheduling and coordination of flagger or signal system personnel or for the availability of HRRC personnel to perform the work, all such costs shall be the responsibility of the Contractor and will not be paid under this ITEM.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Payment under this item will be an ALLOWANCE made based on paid invoice to HRRC for the service provided by the HRRC flagger and system personnel with no markup. No payment shall be made beyond the amount on the invoices. No other payment for other items beyond the scope of this item shall be included.

ITEM 850.42 **WORK TRAINS** **ALLOWANCE**

DESCRIPTION

Upon the Contractor's request, subject to equipment and personnel availability, the Housatonic Railroad Company (HRRC) will, on a limited basis, provide and operate locomotives to move ballast cars and/or air side dump cars within the project corridor for ballast distribution and transport of excess soil and ballast excavation spoils as described in these special provisions.

The Contractor shall be responsible for scheduling and coordinating their work with HRRC. MassDOT is not responsible for delays or any additional costs associated with scheduling and coordination of locomotive power or for the availability of HRRC personnel to perform the work, all such costs shall be the responsibility of the Contractor and will not be paid under this ITEM.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Maximum reimbursement under this ALLOWANCE is capped at the ALLOWANCE amount stated in the bid form. Any costs in excess of the ALLOWANCE amount are the responsibility of the Contractor and will not be paid by MassDOT.

Before permitting work to begin under this ITEM, the Contractor shall request an itemized written estimate from HRRC indicating the cost for the work to be performed. The Contractor shall submit these written estimates to the Engineer for review and approval prior to engagement of HRRC's services. No payments will be made for any services provided under this ITEM without prior review and approval by the Engineer. No payments exceeding the approved estimate amounts will be made by MassDOT.

Payment under this item will be an ALLOWANCE made based on the paid invoice to HRRC for the service provided by the HRRC with no markup. No payment shall be made beyond the amount on the invoices. No other payment for other items beyond the scope of this item shall be included.

ITEM 945.10 DRILLED MICROPILES FOOT
ITEM 948.60 MICROPILE LOAD TEST EACH

GENERAL

This item shall conform to the requirements of all relevant Sections of the Standard Specifications and Supplemental Specifications.

This work shall consist of constructing micropiles as shown on the plans, approved working drawings, and as specified herein. The Contractor is responsible for furnishing all materials, equipment, labor, services, and supervision; and for selecting means and methods for the installation and testing of micropiles for this project.

Micropiles shall consist of permanent casing sections and fully reinforced grout sections bonded with bedrock. Permanent casings shall be included as part of the micropiles and shall remain in place after grouting is complete. Temporary casings shall be installed if necessary to facilitate micropile construction and shall be removed during or after grouting. The Contractor is responsible for drilling through obstructions encountered during pile installation.

The micropiles load capacities shall be confirmed by load testing. Testing must meet the test acceptance criteria specified herein. The bond length of the micropile may be modified by the Engineer, pending results of load testing performed as an initial part of the work.

MATERIALS

The materials for micropiles shall meet the following requirements:

Permanent/Drill Steel Casing used as Reinforcement (Outer Pipe): Permanent steel casing/pipe used as reinforcement shall be new "Prime" steel meeting the requirements of ASTM A252 Gr. 3 with a yield strength of 45 ksi or ASTM A500 Grade B with a yield strength of 46 ksi. The grade of the prime steel casing shall conform to the properties shown on the Plans. The steel outer pipe is to be welded, the Carbon Equivalency, as defined in AWS D1.1 Section XI.1, shall be less than or equal to 0.45, as demonstrated by mill certificates. The sulfur content shall not exceed 0.05%, as demonstrated by mill certificates.

Permanent/Drill Steel Casing used as Reinforcement (Inner Pipe): Permanent steel casing/pipe used as reinforcement shall be new "Prime" steel meeting the requirements of ASTM A252, Grade 3, or API 5L PSL1 pipe with a yield strength of 52 ksi with SR15 supplemental requirements. The grade of the prime steel casing shall conform to the properties shown on the Plans. Alternative permanent steel casing material (such as API 5CT N80 mill secondary pipe with coupon testing and certification of domestic production) must be approved by MassDOT Rail and Transit and the Engineer in writing prior to the bid.

Permanent steel casing shall consist of ERW (Electric Resistance Welded) and/or seamless steel casing and shall be designed to withstand the design loadings determined by the Engineer or shown on the Plans and the load test loading described in this specification.

Joints for permanent steel casing shall develop the full vertical capacity, and at least 60% of the moment capacity of the casing. As installed, there shall be no outer pipe joints within 8 feet from the bottom of the pile cap. The inner pipe joints shall be staggered between 4.5 to 5.5 feet from the outer pipe joints.

The steel casing shall have certified mill test reports and shall be submitted for record purposes as the materials are delivered. The steel shall be traceable back to the mill certifications, and be free from defects (dents, cracks, tears, etc.).

Permanent steel casing shall be installed a minimum of 12 inches into intact bedrock.

Reinforcing Bars: Central reinforcing steel shall be full-length, continuously threaded bars. The bars shall conform to ASTM A615 Grade 75, or ASTM A722 Grade 150. The grade and size of the central reinforcement shall conform to any minimum and/or maximum properties shown on the Plans.

Reinforcing Bar Couplings: Reinforcing bar couplers shall be in accordance with Subsection M8.01.9 but are not required to be listed on the Qualified Construction Materials List (QCML). Where reinforcing bars are not specified with corrosion protection, bar couplers shall not be required to be epoxy coated or galvanized.

Independent testing shall be performed by a nationally recognized testing laboratory, approved by the Engineer, which shall provide certified test results showing that the reinforcing bar coupler meets the requirements of Subsection M8.01.9. Acceptance of the couplers shall be approved by the Engineer.

Centralizers and Spacers: Centralizers and spacers for the reinforcing steel shall be fabricated from schedule 40 PVC pipe or tube, or material non-detrimental to the reinforcing steel. Wood shall not be used.

They shall be securely attached to the reinforcement; sized to position the reinforcement to provide the grout cover specified in the table below; sized to allow grout tremie pipe insertion to the bottom of the drill hole; and sized to allow grout to freely flow up the drill hole and casing.

Table 1 - Minimum Grout Cover for Steel Reinforcement

Condition	Minimum Cover on Bar (in.)	Minimum Cover on Coupler (in.)
Micropiles in Soil	1	¼
Micropiles in Rock	½	¼
Coated or Encapsulated Bars	½	¼

Steel centralizers shall be used on the inner casing to maintain the position of the inner casing within the outer casing while advancing the portion of inner casing that will remain within the outer casing.

Admixtures for Grout: Admixtures shall conform to the requirements of AASHTO M 194 and shall be selected from the QCML where applicable. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations or micropile top connections. Accelerators are not permitted. Admixtures containing intentionally added chlorides are not permitted. Admixtures shall be from the same Manufacturer and shall be compatible with the grout and mixed in accordance with the Manufacturer's recommendations.

Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout subject to review and acceptance by the Engineer.

Cement: All cement shall conform to AASHTO M 85 Type I, Type II, Type III, or Type V and shall be the product of one Manufacturer.

Grout: Neat cement mixture with a minimum 3-day unconfined compressive strength of 2,500 psi and 28-day unconfined compressive strength of 5,000 psi. The grout shall be proportioned and mixed with a high-shear colloidal mixer as to provide a fluid grout capable of maintaining the solids in suspension without appreciable bleed. Preparation and placement of grout shall be in accordance with the recommendations of "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete," ACI 304.

A minimum of 60 calendar days prior to the start of micropile construction the grout mix design shall be submitted to the Engineer and a trial batch shall be performed. The trial batch shall take place at a location approved by the Engineer and be performed in the presence of Department personnel and/or Engineer. It shall be representative of the production grout placement and shall consist of the same materials, equipment, methods of mixing, and sample preparation and curing methods.

Provide trial batch samples and testing results to verify that the material meets all grout criteria specified in Table 2. The quantity of material batched shall be sufficient to perform all required tests specified.

Table 2 – Grout Material Acceptance Criteria for Trial Batch Testing

Quality Characteristic	Test Method	Engineering Limit
Minimum Compressive Strength:	AASHTO T 106	
3 days		≥ 2,500 psi
7 days		For information only
28 days		≥ 5,000 psi
Consistency	API RP-13B-1	± 10% of the density specified in the mix design

Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to M8.05.0, AASHTO M 270, and have minimum yield strength of 50 ksi.

Water: Water for mixing grout shall be potable, clean, and free from substances that may be injurious to cement and steel.

Fillers: Inert fillers such as sand (conforming to AASHTO M 45) may be used in the grout in special situations, such as presence of large voids in the ground or when grout take and travel are to be limited, with prior written approval by the Engineer.

CONSTRUCTION METHODS

QUALIFICATIONS

The Micropile Contractor must be experienced in the construction and load testing of micropiles and have successfully constructed at least 5 projects in the last 5 years involving construction totaling at least 100 micropiles with similar capacity and requirements specified in these plans and specifications. The Micropile Contractor shall have previous micropile drilling and grouting experience in soil/rock similar to project conditions and shall have available and be thoroughly familiar with the specialized type of equipment needed to perform work of this type. The Micropile Contactor must have constructed at 3 projects in the last 5 years involving drilling and construction within a railroad right of way.

The on-site foremen and drill rig operators shall also have experience on at least 3 projects over the past 5 years installing micropiles of equal or greater capacity than required in these plans and specifications.

Prior to the Pre-construction Meeting, the Micropile Contractor shall submit the following information to verify the firm's experience and the qualifications of personnel scheduled to perform the micropile design (load test frame) and construction:

1. Submit a list of at least five micropile projects successfully completed in the last five years. Include construction details, structural details, load test reports, and client contact for each project listed.

2. Submit a list of at least three micropile projects successfully completed in the last five years within railroad right of ways. Include construction details, structural details, load test reports, and client contact for each project listed.
3. Submit a list of the equipment and resources the Micropile Contractor plans to mobilize and utilize for the performance of the project.
4. Provide the names and detail the experience of the micropile designer, on-site supervisor, foremen, and drill rig operators for this project.
5. A signed statement that the Micropile Contractor has inspected both the project site and all the subsurface information including any soil or rock samples made available in the Contract Documents.

Work on any micropiles shall not be started, nor materials ordered until the qualifications and submittals have been accepted by the Engineer. The Engineer may suspend the micropile construction if the Micropile Contractor substitutes unapproved personnel during construction. Requests for substitution of field personnel shall be submitted to the Engineer for acceptance. Additional costs resulting from the suspension of work will be the Micropile Contractor's responsibility, and no extension in contract completion date resulting from the suspension of work will be allowed.

The Micropile Contractor shall have, on site during all micropile construction activity, a minimum of one Quality Control (QC) inspector. This person shall be responsible for quality control of the micropiles during all phases of construction and will monitor and document all QC inspection and testing activities required by the specifications and outlined in the accepted procedures and Working Drawings. The QC person shall be a certified NETTCP Concrete Technician.

MICROPILE PRE-CONSTRUCTION SUBMITTALS

The Contractor shall prepare and submit to the Engineer: shop drawings, a micropile installation plan, construction procedures, load testing procedures, and equipment calibrations for review and acceptance. The Contractor shall verify the limits of the micropile structure before preparing the detailed working drawings and allow the Engineer four (4) weeks to review the submittal after a complete set has been received. Work shall not begin, nor materials ordered until all submittals have been received, reviewed, and accepted in writing by the Engineer.

The micropile submittals shall include:

A. <u>Plans</u>

1. A plan view of the micropile layout identifying the locations of micropiles, numbering system for records, and load test micropile locations.

2. An elevation view of the test micropile(s) showing:
    i. A typical detail of test micropiles defining the micropile length, reinforcement, inclination, and load test bonded and unbonded test lengths.
    ii. Permanent casing length and diameter, casing plunge length, and grout bond zone length.
    iii. Estimated soil/bedrock strata.
    iv. Instrumentation to be installed.
    v. Minimum drill hole diameter.
    vi. Splice type and locations.
    vii. Centralizers and spacers for reinforcing bars and inner casings.
    viii. Corrosion protection details.
    ix. Grout design strength.

3. Details for constructing micropile structures around utilities, as applicable.

B. <u>Construction Procedures</u>

1. Detailed step-by-step description of the proposed micropile construction procedure, including personnel, testing, and equipment to assure quality control. This step-by-step procedure shall be shown in sufficient detail to allow the Engineer to monitor the construction and quality of the micropiles. Include methods of drilling the holes, advancing the casing, drilling through or removing obstructions, flushing drilled holes, installing reinforcement, and grout pressures.

2. If welding of casing is proposed, submit the welding procedure. All welding shall be done in accordance with the current AWS Structural Welding Code.

3. Information on space requirements for installation equipment that verify the proposed equipment can perform at the site.

4. Plan describing how surface water, drill flush, and excess waste grout will be controlled, contained, and disposed. Excavated soil can be disposed of at a location within the railroad right-of-way as directed by Housatonic Railroad. Drilling fluid and other construction related waste, including excess grout shall be disposed of offsite in accordance with related specifications within the Contract Documents, and all applicable local codes and regulations.

5. Certified mill test reports for the central reinforcing steel. The ultimate strength, yield strength, elongation, and material properties composition shall be included.

6. Certified mill test reports for the permanent casing. Certification that the permanent casing meets the supplemental requirements of SR15 shall be included.

7. Quality Control Plan. The QC Plan should sufficiently document the QC processes of all Contractor parties (i.e. Prime Contractor and Subcontractors) performing work required under this specification. The QC Plan shall be structured to follow the format and section headings outlined in the MassDOT Model QC Plan. It shall be submitted to the Engineer for review and approval a minimum of 30 days prior to the start of work.

   The QC Plan shall include complete descriptions, and details for the following:

   i. Micropile installation including drilling method and grouting procedure.
   ii. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports. The Micropile Contractor shall also provide specific gravity and density of the wet mix design.
   iii. Methods and equipment for accurately monitoring and recording the grout depth and grout volume as the grout is being placed.
   iv. Estimated curing time for grout to achieve specified strength. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification and acceptance, and start of production work. During production, grout shall be tested in accordance with the Grout Testing Requirement specified herein.
   v. Procedure and equipment for Micropile Contractor monitoring of grout quality. At a minimum, the Micropile Contractor shall verify the specific gravity of the mixed grout prior to placement of the grout into each drilled micropile.
   vi. Manufacturer details on 2-inch cube molds for strength testing of grout.

C. Load Testing Procedures

Detailed plans and procedures for the proposed micropile load testing method. This shall include all drawings, details, and structural design calculations necessary to clearly describe the proposed test method, reaction load system capacity and equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements in accordance with the Micropile Load Testing section of this specification.
Design of the test pile and reaction load system shall be stamped by a Professional Engineer registered in the Commonwealth of Massachusetts retained by the Contractor.

D. Equipment Calibration

Calibration reports and data for each test jack, pressure gauge, master pressure gauge, and electronic load cell to be used. The calibration tests shall have been performed by a certified testing laboratory, and tests shall have been performed within 90 calendar days of the date submitted. Testing shall not commence until the Engineer has reviewed and accepted the jack, pressure gauge, master pressure gauge, and electronic load cell calibration data.

PRE-CONSTRUCTION MEETING

A mandatory pre-construction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Design Consultant, MassDOT Resident Engineer, , Prime Contractor, Pile Contractor and other major subcontractors, including QC personnel, shall attend the meeting. The preconstruction meeting will be conducted to clarify the construction and QC requirements for the work, to coordinate the construction schedule and activities, specifically those pertaining to excavation for pile structures, installation of temporary sheeting, anticipated subsurface conditions, pile installation and testing, pile structure survey control, and site drainage control.

SITE DRAINAGE CONTROL

The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accordance with related specifications within the Contract Documents, and all applicable local codes and regulations. Provide positive control and discharge of all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the work, remove surface water control pipes or conduits from the site.

EXCAVATION

Coordinate the work and the excavation so the micropile structures are safely constructed and remain stable at all times. Perform the micropile construction and related excavation in accordance with the plans and accepted submittals. No excavation deeper than those specified herein or shown on the plans will be made above or below the micropile structure locations without written acceptance of the Engineer.

MICROPILE INSTALLATION

A. General

The Micropile Contractor shall select the drilling method, the grouting procedure, and the grout pressure used for installation of the micropiles. The construction method shall incorporate any special construction requirements specified on the plans. The production micropiles and its construction method shall be identical to the accepted test pile.

When the plans require uncased drilling of the micropile into bedrock, the permanent and/or temporary casing shall be drilled a minimum 12 inches into intact bedrock or to a depth within the bedrock so as to prevent subsidence of over burden into the uncased and/or bond zone portion of the drill hole (i.e. the rock socket).

Piles shall be installed only in the presence of the Engineer's or MassDOT's Representative.

Control and contain all drill cuttings and drill fluids to protect the resource area around the site. Legally dispose of all drill fluids and excess drill cuttings.

Protect ballast from contamination by drill cuttings or grout. Remove and replace any ballast that is contaminated by drill cuttings or grout at no additional cost to MassDOT.

B. Location and Survey

Micropiles shall be located and marked using survey and a template by the Contractor who shall maintain and be responsible for all location and elevation stakes.

C. Drilling

The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, without causing damage to overlying or adjacent structures, buried structures, or utilities.

Temporary casing or other accepted method of pile drill hole support is required, when drilling within 10 feet of an existing foundation, or utility, and/or in caving or unstable ground, to permit the pile shaft to be formed to the minimum design drill hole diameter. The casing shall be of the type and thickness that can be installed without distortion. Casings that fail, fracture, or otherwise distort during drilling or after drilling shall, unless otherwise directed, be withdrawn or replaced at the Contractor's expense. The drill hole must be open along its full length to at least the design minimum drill hole diameter prior to placing grout and reinforcement. The Contractor's proposed method(s) to provide drill hole support and to prevent detrimental ground movements shall be reviewed by the Engineer. Detrimental ground movement is defined as movement which requires remedial repair measures, in order to maintain site conditions as determined by the Engineer. Do not progress a new hole, pressure-grout, or post-grout, within a radius of 5 pile diameters or 10 feet, whichever is greater, of a micropile until the grout for that micropile has set 24 hours or longer. Do not allow vibration or excessive wheel loads to influence piles during installation and construction.

Use of drilling fluid containing bentonite or any other non-reverting drilling fluid is not permitted. Use of polymer slurry to remove cuttings from the cased hole shall be approved by the Engineer.

Piles shall be installed using equipment capable of penetrating boulders, cobbles, bedrock, dense till material, granite blocks, timber, concrete, or other man-placed materials that hinder the advance of the pile.

Use of drop-type impact hammers and blasting are not permitted. Prior to the use of down the hole air drilling methods the Contractor shall provide temporary fencing or barriers as necessary to prevent cuttings from leaving the work area and entering the adjacent traffic lanes.
Micropiles shall not be installed using auger cast methods.

Permanent casing must be installed in a manner which will not loosen the adjacent soils and will result in intimate contact between the casing and the soil. Driving of casing will not be allowed. Drilling shall be performed such that cuttings and/or wash fluid return through the inside of the casing. External flush will not be allowed. The method of drilling used shall prevent the loss of ground due to erosion, jetting, or blow-in at the bottom of the casing. No open-hole drilling will be allowed unless accepted by the Engineer.

Control drilling fluid and dispose of spoil in accordance with the approved procedure.

D. Ground Heave or Subsidence

During construction, the Contractor shall observe the ground conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the Engineer if signs of movements are observed. The Contractor shall immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor’s methods or operations or failure to follow the specified/accepted construction sequence, as determined by the Engineer, the costs of providing corrective actions will be borne by the Contractor.

E. Pipe Casing and Reinforcing Bars Placement and Splicing

Reinforcement shall be placed prior to grouting the drill hole. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease, or oil that might contaminate the grout or coat the reinforcement and impair bond. Reinforcement in the bond zone [i.e. rock socket] shall extend the minimum required length.

The Contractor shall install all micropiles to the planned elevations.

Centralizers and spacers shall be provided at a maximum spacing of 10 feet on center on both the inner casing and the reinforcing bar. The upper- and lower-most centralizers shall be located a maximum of 5 feet from the top and bottom of the micropile, respectively. Centralizers and spacers shall permit the free flow of grout without misalignment of the

reinforcing bar(s) and permanent casing. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. The Contractor shall re-drill and reinsert reinforcing steel when necessary to facilitate insertion.

Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Splices and threaded joints shall meet the requirements of the Material section. Threaded pipe casing joints shall be located at least two casing outside diameters (O.D.) from a splice in any reinforcing bar. When multiple bars are used, bar splices shall be staggered at least 1 foot.

F. Grouting

The grouting equipment shall produce a grout free of lumps and undispersed cement. Admixtures, if used, shall be mixed in accordance with Manufacturer's recommendations. The Contractor shall have means and methods of measuring the grout quantity and pumping pressures during the grouting operations. The grout pump shall be a positive displacement pump equipped with a pressure gauge to monitor grout pressure. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauge shall be capable of measuring pressures of at least 145 psi or twice the actual grout pressure used, whichever is greater. The grout shall be kept in agitation prior to pumping. Grout shall be placed within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. The grout volume being pumped shall be measured to an accuracy of 10 percent.

Micropiles shall be grouted the same day the load transfer bond length is drilled. The annular space between the outer pipe and the inner pipe shall be flushed with clean water to within two feet of the bottom of the outer pipe. The depth of the annular space between the outer pipe and the inner pipe shall be sounded to verify cuttings have been removed. The bond length and the inner pipe shall then be flushed with clean water immediately prior to grouting, to remove all contaminated water and cuttings. The hole shall be flushed through the grout pipe fully extended to the bottom of the hole. The water shall be pumped at a high velocity until the wash water at the top of the casing is clear. After flushing, the depth of the hole shall be measured to confirm that the hole is clean and no sediment exists at the bottom of the drilled rock-socket/bond length. Installation of the steel reinforcing and grouting shall be done immediately after flushing. In case of delay, the hole shall be re-flushed and rechecked prior to grouting as directed by the Engineer. Care shall be taken to prevent cuttings from falling into the annular space between the outer casing and the inner casing while flushing the bond zone and the inner casing.

The grout shall be injected from the lowest point of the drill hole, and injection shall continue until uncontaminated grout flows from the top of the pile. The annular space between the outer and inner casings shall be temporarily sealed to prevent contamination of the annular space during grouting of the bond zone and inner pipe. Upon completion of

grouting the bond zone and the inner casing, grout shall be injected from the lowest point of the annular space between the outer and inner pipes, and injection shall continue until uncontaminated grout flows from the top of the annular space. The use of compressed air to directly pressurize the fluid grout takes is not permissible. The tremie pipe or casing shall always extend below the level of the existing grout in the drill hole during grouting procedures. The grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations. The entire micropile shall be grouted to the design cut-off level. Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout.

If the Contractor elects to use a post-grouting system, Working Drawings and relevant details including grouting pressure, volume, location and mix design, shall be submitted to the Engineer for review.

G. Construction Tolerance

Unless otherwise stated on the Plans, the following shall be the maximum construction tolerances for micropiles:

1. Centerline of piling shall not be more than 2 inches from indicated plan location.
2. Pile shall be plumb within 2 percent of total-length design plan alignment.
3. Battered piles inclined greater than 1:8 shall be within 6 percent of design plan alignment.
4. Top elevation of pile shall be plus or minus 1/8 inch maximum from vertical design elevation indicated.
5. Centerline of reinforcing steel shall not be more than 3/4 inches from indicated center of pile.
6. Minimum volume of grout placed shall be 110% of the theoretical volume of the whole micropile length from bottom to top at time of grouting.

H. Micropile Installation Records

The Contractor shall prepare and submit to the Engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on a micropile installation log. A separate log shall be provided for each micropile. The log for each micropile shall contain the following minimum information:

1. Project name, structure name, micropile number, and contract number.
2. Date and time of drilling, grouting, and completion.
3. Bottom elevation of the proposed pile cap and final top elevation of the micropile, to the nearest 0.1 feet.
4. Plumbness and deviation from design location and batter.

5. Micropile as-built information such as pile inclination, casing diameter and wall thickness, reinforcement size and length, casing length below bottom of pile cap, taped measurement inside casing to check cleanout, plunge length (cased bond length), bond length below casing, and total pile length below and above bottom of pile cap. All dimensions shall be provided to the nearest 0.1 feet.
6. Drilling method, drill bit type and size, and drill operator's name.
7. Table showing the descriptions and approximate top and bottom elevation of each soil or rock layer encountered during pile drilling.
8. Grout mix, density, and quantity used, for initial grout and post-grout (if any) including cement type and admixtures.
9. Maximum and average grout pressure used during installation.
10. Damage (if any) to pile, description of any deviations from the design location and batter or from the approved pile design and installation procedures, and description of any unusual occurrences during drilling (including obstructions), installation, and grouting.

The example micropile installation log in the "Micropile Design and Construction Guidelines Manual," Report No. FHWA-NHI-05-039 or FHWA-SA-97-070 can be used as a reference in developing the micropile installation log.

The Contractor shall also submit within 2 weeks after installation of all piles, an as-built plan, certified by a surveyor, showing the as-installed location of all piles to the nearest ½ inch.

CONSTRUCTION QUALITY ASSURANCE

Contractor Quality Control

The Contractor's QC personnel will perform Quality Control inspection, sampling, and testing to ensure that the processes are providing work conforming to the contract requirements. Inspection, sampling, and testing shall be documented on appropriate forms and provided to the Engineer. The Engineer will not sample or test for Quality Control or assist in controlling the Contractor's operations.

A. <u>Testing</u>

1. Grout consistency: As measured by grout density shall be determined by the Contractor per API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat

cement grout. The measured grout density shall be within ±5% of the density specified in the grout mix design submittal.

2. Compressive Strength: Grout within the micropiles shall be tested by the Contractor's Quality Control Inspector to ensure that it attains the minimum required compressive strength.

   Micropile grout shall be sampled and cured in accordance with AASHTO R 64 (for 2 inch by 2 inch cubes) and tested for compressive strength in accordance with AASHTO T 106 (for cubes). Grout samples shall be taken directly from the grout plant (on-site mixer and pump).

   The QC Technician will take the following sets of grout samples for QC testing:

   i. Test Pile – three (3) sets of three (3) cubes for 3-, 7-, and 28-day strength testing.

   ii. Production Piles – one (1) set of three (3) cubes for 28-day strength testing for every two (2) micropiles or one set from each grout plant on each day of operation; whichever occurs more frequently.

   The Contractor shall provide grout cube compressive strength, grout density, and grout volume results to the Engineer within 24 hours of testing.

   Specific gravity of the grout mix shall be measured for each batch of grout mixed. Specific gravity measurement shall be recorded on the pile log.

<u>Table 3 – Grout Material Acceptance Criteria</u>

Quality Characteristic	Test Method	Engineering Limit
Minimum Compressive Strength:		
3 days	AASHTO T 106	≥ 2,500 psi
7 days		For information only
28 days		≥ 5,000 psi
Consistency	API RP-13B-1	± 10% of the density specified in the mix design
Volume		≥ Theoretical volume of hole

MassDOT Acceptance

The Engineer is responsible for performing all Acceptance activities and making the final Acceptance determination. The Engineer's Acceptance system will include monitoring the

Contractor's QC activity, performing Acceptance inspection, and utilizing available sampling and testing data.

A. Inspection

The Engineer will perform Acceptance inspection of all work items to ensure that all materials and completed work are in conformance with the contract requirements.

B. Testing

The Contractor will be required to provide to MassDOT a sufficient amount of approved 2-inch cube molds.

MassDOT may take the following sets of grout samples for Acceptance testing:

i. Test Pile – 3 sets of cubes for 3-, 7-, and 28-day strength testing.

ii. Production Piles – one (1) set of three (3) cubes for 28-day strength testing for every two (2) micropiles or one set from each grout plant on each day of operation; whichever occurs more frequently.

Pile load testing shall not be performed until MassDOT has confirmed the grout has reached the minimum 3-day design strength specified in Table 4.

Table 4 – Grout Material Acceptance Criteria

Quality Characteristic	Test Method	Engineering Limit
Minimum Compressive Strength:		
3 days	AASHTO T 106	≥ 2,500 psi
7 days		For information only
28 days		≥ 5,000 psi

MICROPILE LOAD TESTING

Perform one pile load test as a tension test, to at least __520_ kips for Br. 77.04 and 680 kips for Br. 79.81 (2 times the design capacity of __260_ kips for Br. 77.04 and 340 kips for Br. 79.81) on a sacrificial micropile for each bridge. Perform the test in accordance with ASTM D3689 and the following requirements:

The sacrificial test pile shall be installed where shown in the Contract Documents.

1. The test pile shall have a bond-breaker sheath installed over the core bar to ensure that the full test load is transmitted to the top of the load test bond zone.

The maximum design load shall be taken as 50% of the applied test load which results in a movement under load of 0.5 inch (13 mm) at the pile tip. The movement at the pile tip shall be:

measured directly by a tell-tale; or

computed by deducting the theoretical elastic elongation of the pile from the displacement measured at the top of the pile.

Load tests shall be conducted, the test results evaluated, and the method of pile installation approved by the Engineer prior to installing the production piles. The test pile will not be reused as a production pile.

Before starting the work, the Contractor shall submit to the Engineer for acceptance, a pile load test plan including a written description of the equipment and methods which are intended to be used. The methods must be of an accepted type and shall be altered as necessary to meet the acceptance of the Engineer. The pile load test plan and description shall be prepared and stamped by a professional engineer registered in the Commonwealth of Massachusetts.

The Contractor shall provide all personnel and equipment needed to perform the test, measure loads and movements, and record test data. A representative of the Department or the Engineer may observe and witness the test and record data independently. No testing is to be performed unless all the agreed representatives are present.

The load test pile shall be identical to the production piles and installed using the same procedures, with the following exceptions:

The test pile shall include one telltale located at the pile tip.

The test pile shall include a bond-breaker sheath over the core bar as described in paragraph A.2 above.

Allow the grout in the test pile to cure for a minimum of 7 days before testing. Type III (high early) cement can be used for the test pile to reduce the required cure time, subject to approval by the Engineer.

The steel core bar may have to be a higher strength steel or a larger size than for the production piles to accommodate the test load.

Apply the load to the steel core bar by means of a single hydraulic jack. Construct the apparatus for applying the loads to the test pile so that the loads are applied axially to the pile. Align the jack, bearing plates and stressing anchorage such that unloading and repositioning of the equipment will not be required during the test. Calibrate the test load jacking system including the hydraulic jack, couplings, hydraulic pump, and pressure gauge prior to the test so that the load applied is controlled to within 3 percent of the total applied load. Submit calibration reports prior to the start of the pile load tests.

Provide all necessary materials and labor for construction of a displacement measuring system for each test, as follows:

Provide a steel reference beam with a maximum moment of inertia of no less than 105 inches^4 about its neutral axis of rotation. The reference beam must be independently supported with supports firmly embedded in the ground at a distance of between 8 and 10 feet from the test pile and not less than 8 feet from any reaction pile or bearing pad. One end of the reference beam must be free to move as the length of the beam changes with temperature variations.

Mount three dial gauges equidistant from the center of the test pile and at 120-degree intervals around the pile. Attach the dial gauges rigidly to the reference beam. Align gauge stems vertically to bear on the reference points attached to the pile. Provide smooth glass horizontal bearing surfaces for the gauge stems. Dial gauges shall have at least a 2-inch travel and shall read to 0.001 inch.

Establish a survey reference point on the test pile and at each end or at the center of the reference beam. The reference points shall consist of graduated scales machine-divided into 0.02 inch and attached securely to the pile and reference beam. The reference points shall be monitored using survey equipment during the pile load test.

Protect the settlement measuring system against rain, wind, frost, and any other disturbances that could affect the reliability of the settlement observations. Provide sun-shading for the measuring system for the duration of the test and for a minimum of 1 hour prior to the start of the test.

Provide one telltale attached to the bottom of the pile. Provide dial gauges to measure the displacement of the telltale. The dial gauges must have a minimum of 2 inches travel and read to 0.001 inch.

Use the following loading procedure:

Apply 25% of the proposed allowable design load every 0.5 hour. Longer time increments may be used, but each time increment should be the same. In no case shall a load be changed if the rate of settlement is not decreasing with time.

At 200% of the proposed allowable design load maintain the load for a minimum of one hour and until the settlement (measured at the lowest point on the element at which measurements are made) over a one-hour period is not greater than 0.01 in.

Remove 50% of the design load every 15 minutes until zero load is reached. Longer time increments may be used, but each should be the same. Measure rebound at zero load for a minimum of one hour.

For each load increment or decrement, take readings at the top of the element and on the instrumentation at one, two, four, eight and 15 minutes and at 15-minute intervals thereafter.

A load greater than 200% of the proposed allowable design load may be applied at the top of the test element, using the above loading procedure, to ensure that the requirement for minimum load reaching the bearing stratum is fulfilled.

Submit a detailed report including such information as pile location, type, diameter, length, displacement readings, and all other pertinent data as indicated in ASTM D3689.

The test pile will not be used as a production pile. After the load test, the test pile shall be fully grouted and shall be cut off 3 feet below the design cutoff elevation for production piles in that area.

NON-CONFORMING PILES

Non-conforming piles include piles that are installed out of tolerance, are damaged, the volume of grout placed is less than the theoretical volume of the hole, or the grout tests do not indicate the specified strength has been achieved. The Contractor shall submit a written remedial action plan to the Engineer for approval. The remedial action plan shall indicate how to correct the problem and prevent its reoccurrence. To mitigate or remediate non-conforming piles, the Contractor may be required to provide additional piles or supplement piles to meet specified requirements at no additional cost to the Owner.

METHOD OF MEASUREMENT

Drilled Micropiles will be paid for at the contract unit price per Foot.

Micropile Load Test shall be measured for payment per Each.

BASIS OF PAYMENT

Drilled Micropiles shall be paid at the contract unit price per Foot, complete in place and accepted. Payment for drilled micropiles shall be considered complete compensation for providing all materials, labor, equipment, proper disposal of drilling spoil, and incidentals to complete the work. There will be no separate measurement for mobilization and demobilization associated with this item. Any difference in the required length of permanent casing and micropile installed and accepted by the Engineer from the estimated lengths shall be measured for payment and/or credit. There will be no payment for differences in required length of temporary casing. The Micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

The Contractor shall anticipate encountering obstructions as noted herein and shall utilize equipment and methods necessary to advance through or remove the obstructions. The presence of obstructions, any lost production, replacement piles, and the removal of obstructions, if necessary, shall not be measured or paid for separately. Any costs associated with the presence of obstructions shall be considered incidental to the Drilled Micropiles Item.

Drilling tools that are lost during the drilling shall not be considered obstructions and shall be promptly removed by the Contractor without compensation. If removal will degrade the hole, the hole shall be abandoned with a new hole located by the Engineer. All costs due to

lost tool removal, drilling a new hole and filling the abandoned hole shall be borne by the Contractor.

Micropile Load Test shall be paid at the contract unit price per each completed and accepted test, for which payment shall be considered complete compensation for providing all design, materials, labor, equipment, load test report, and incidentals to complete the work including the installation and materials of the test pile and reaction piles, if used. This payment shall also include full compensation for cutting the pile to the elevation necessary to properly incorporate the pile in the structure. If a pile is not to be incorporated in the structure, this payment item includes cutting the pile to the grade necessary to avoid its interference with the proposed construction. Payment for Micropile Load Tests shall also include full compensation for installing the test pile.

Payment Items

945.10	Drilled Micropiles	Foot
948.60	Micropile Load Test	Each

ITEM 952.0 **STEEL SHEET PILE** **LB**

1.01 DESCRIPTION

A. The work under this item shall conform to the relevant provisions of Section 950 of MassDOT Standard Specifications and the following:

B. Section Includes:

1. Furnishing and installing permanent steel sheet pile for:

   a. Sheet pile in front of abutments of Bridge No. 79.81.

   b. Sheet pile for wingwalls of Bridge No. 79.81 including tie rods, wales and all related items.

2. Temporary track supports between end bents and proposed sheet pile walls at Bridge No. 79.81, as described on plans.

C. ASTM International:

1. A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.

2. A563 – Standard Specification for Carbon and Alloy Steel Nuts.

3. A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

4. A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

D. American Welding Society:

1. AWS D1.1 – Structural Welding Code – Steel.

1.02 DESIGN REQUIREMENTS

A. Required sheet pile sections are shown on the Drawings.

B. Alternate Designs: Contractor may propose alternate sheet pile sizes or design for consideration by the Engineer:

1. Design sheet pile to provide structural capacity and stiffness equal to or

greater than capacity and stiffness of specified piling.

2. Design sheet pile configuration using standard published manufacturer's properties.

3. Furnish required submittals signed and sealed by a professional engineer registered in the Commonwealth of Massachusetts.

4. Design sheet pile as permanent structure to be left in place in completed construction.

C. Designs for temporary track supports and temporary sheet pile supports shall be in accordance with the latest edition of American Railway Engineering and Maintenance -of-way Association (AREMA) "Manual for Railway Engineering.

1.03 SUBMITTALS

A. Shop Drawings for Steel Sheet Pile:

1. Indicate plan location and extent of sheet pile and cut off method.

2. Include complete dimensions and details of sheet pile sections including sheet pile accessories or special piles at corners.

3. Include sequence of driving and detailed drawings of templates or other temporary guide structures.

4. Submit list and size of proposed equipment including cranes, barges, matting, driving equipment, extractors, protection caps, and other installation accessories.

5. Submit detailed procedures and features for protection of existing structures or other installations.

6. Include details of storage and handling procedures.

7. Grouting procedure for filling the annular space between the tie rods and the pipe sleeves.

B. Design for Temporary Supports:

1. Calculations and drawings of temporary track supports between steel sheet pile and bents shall be prepared and stamped by a professional engineer registered in the Commonwealth of Massachusetts and submitted to the

Engineer for review before installation of steel sheet pile. Cost of temporary support shall be incidental to steel sheet pile.

2. Contractor is responsible for design of the sheet pile walls under temporary conditions during construction. Design and analysis of the sheet pile walls in the temporary condition shall be prepared and stamped by a professional structural engineer registered in the Commonwealth of Massachusetts and submitted to the Engineer for review before installation. Sheet piles shall be analyzed for Cooper E80 loading and construction surcharges. Design shall include construction sequence, sheet pile tip elevations and sizes, temporary bracing, and construction surcharge criteria including minimum setbacks. Cost of temporary support shall be incidental to steel sheet pile.

C. Product Data:

1. Submit mill test reports for sheet pile, structural steel, and tie rods, description of pile driving equipment, and certification of interlocking joint strength.

2. Include manufacturer’s data sheets on cranes and driving equipment.

1.04 CLOSEOUT SUBMITTALS

A. Project Record Documents:

1. Record actual locations of sheet pile and top and bottom elevations.

2. Survey plan showing all sheet piles left in place (permanent and temporary sheets that are abandoned in place) and tie rods. Report coordinates for each sheet pile interlock in tabular format on the survey plan. Plan shall be prepared and stamped by a Professional Surveyor registered in the Commonwealth of Massachusetts and retained by the Contractor.

3. Provide driving records with hammer blows for final 12 inches of driving if an impact hammer is used.

1.05 QUALITY ASSURANCE

A. Perform welding in accordance with AWS D1.1.

B. Furnish each type of sheet pile from a single source.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years' experience.

B. Installer: Company specializing in performing work of this section with minimum five years' experience.

C. Welders and Welding Procedures: AWS D1.1 qualified within previous 12 months.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver sheet pile with manufacturer's logo and mill identification mark on each sheet pile.

B. Handle using handling holes or lifting devices to prevent damage. Lift sheet pile to prevent permanent deformation.

C. Support on level racks spaced not more than 10 feet apart nor more than 2 feet from ends. Arrange supports for multiple lifts aligned vertically.

D. Protect sheet pile to prevent damage.

1.10 SCHEDULING

A. Schedule sheet pile submittals sufficiently in advance of pre-installation meeting to ensure Engineer's review is complete.

PART 2 PRODUCTS

2.01 STEEL SHEET PILE – Z SHAPE, HOT ROLLED

A. Sheet pile: PZ 35, manufactured by Skyline Steel (Nucor) or approved equivalent.

B. ASTM A572, Fy: 50 ksi.

2.02 ANCHORAGE SYSTEM FOR WINGWALLS

A. Double-Channel Wale: ASTM A572 Grade 50.

B. Plates: ASTM A572 Grade 50.

C. Tie Rods: ASTM A615 Grade 75 thread bar with compatible nuts and hardware

as supplied by bar manufacturer.

D. Weld Filler Metal: 70 ksi, meeting the requirements of AWS D1.1.

2.03 SOURCE QUALITY CONTROL

A. Interlock Tension Strength Test: Conform to piling manufacturer’s standard test. Test at least two 3-inch-long coupons taken randomly from different as-produced pilings of each heat.

PART 3 EXECUTION

3.01 TEMPLATES

A. Provide template or driving frame suitable for aligning, supporting, and maintaining sheet pile in correct position during setting and driving.

3.02 PREPARATION

A. Verify equipment on site conforms to approved Submittal.

B. Use driving method that will not cause damage to nearby structures.

C. Protect nearby structures including overhead and buried utilities from damage.

3.03 PILING HAMMER

A. Keep hammer in good mechanical condition.

B. Operate hammer at speed and pressure recommended by manufacturer.

C. Use protective cap during driving to prevent damage to top of sheet pile.

3.04 PERMANENT SHEET PILE INSTALLATION

A. Drive sheet pile only in presence of the Engineer.

B. Align top of sheet pile normal to driving force of piling, hammer, and leads to minimize bowing of piling during installation.

C. Maintain sheet pile vertical during driving.

1. Drive Z piling with male interlock forward or leading.

2. Drive Z piling in pairs.

D. Pre-drilling or pre-trenching may be needed to clear obstructions.

E. Jetting of sheet pile is not permitted unless approved by the Engineer in writing.

F. Drive sheet pile to minimum tip penetration indicated on Drawings.

G. Do not damage sheet pile during driving operations.

3.05 PERMANENT SHEET PILE ERECTION TOLERANCES

A. Maximum Variation from Vertical for Plumb Sheet pile: 1:48.

B. Maximum Variation from Sheet pile Cut-Off Elevation: 2 inches.

C. Maximum Out-of-Position: 2 inches.

3.06 FIELD QUALITY CONTROL

A. Inspect for imperfections in joint interlock capable of impeding installation.

B. Reject damaged sheet pile sections or repair as required prior to installing.

3.07 INSTALLATION OF TIE RODS

A. Perform all welding in accordance with the requirements of AWS D1.1 using certified welders.

B. Tolerances: Wale and tie rod elevation +/- 0.1 foot; tie rod location in plan 0.1 foot;

C. Burn holes in sheet piles for tie rods minimum 2-3/4” diameter, maximum 3-3/4” diameter.

D. Weld brackets to support wale at indicated elevation and set wale at required elevation.

E. Install tie rods through previously placed pipe sleeves below the approach slab.

F. Install bearing plates and hardware as shown on Drawings. Draw tie rods snug tight.

G. Grout the annular space between the tie rods and the inside of the pipe sleeves.

PART 4 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

4.01 METHOD OF MEASURMENT

A. Per pound for steel sheet pile, as measured from top of sheet pile [after cut-off] to bottom of sheet pile at driven elevation and longitudinally along centerline of top of sheet pile.

B. Items for which no specific pay item is identified shall be considered incidental to Item 995.02, Bridge Work for Bridge 79.81.

4.02 BASIS OF PAYMENT

Unit price for steel sheet pile includes but is not limited to labor, equipment, materials, field engineering and preparation, furnishing, pre-trenching or predrilling for clearing obstructions, installing, and cutting off steel sheet pile. The unit price also includes but is not limited to all permanent wales, support brackets, tie rods, pre-stressing of tie rods, hardware, tie rod pipe sleeves, grouting of pipe sleeves, as well as excavation, excavation support and backfilling for installation of sheet piles, wales and tie rods. Temporary remove and reinstall track for installation of sheet pile shall be incidental to Item 952.0 Steel Sheet Pile. Design, furnish and installation of temporary track supports between end bents and proposed sheet pile walls shall be incidental to Item 995.02, Bridge Structure, Bridge No. 79.81.

ITEM 991.1 CONTROL OF WATER – BRIDGE NO. 77.04 LUMP SUM
ITEM 991.2 CONTROL OF WATER – BRIDGE NO. 79.81 LUMP SUM

GENERAL

The work to be performed under Item 991.1 shall include all pumping, sandbagging, earth, and other measures, required for maintaining for sufficient water control, for retaining adjacent embankments, and for accomplishing the demolition of the existing structure and the construction of the proposed foundations and revement for Bridge No 77.04.

The work to be performed under Item 991.2 shall include all pumping, sandbagging, earth, and other measures, required for maintaining for sufficient water control, for retaining adjacent embankments, and for accomplishing the demolition of the existing structure and the construction of the proposed foundations for Bridge No 79.81.

Dewatering shall be conducted to ensure that all structural concrete is placed and cured in the dry.

For demolition purposes, dewatering shall be conducted on an as needed basis as determined by the Contractor. It is the responsibility of the Contractor to determine the need and extent of dewatering required and to submit methods and materials he proposes to use for the Engineer's approval.

The water flow under the bridges shall be maintained during construction.

CONSTRUCTION METHODS

Plans and calculations for all sandbagging, earth, and other water control measures shall be developed by the Contractor for this item. These plans and calculations shall be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts and shall be submitted for the approval of the Engineer prior to the start of construction.

The Contractor shall use such equipment and shall perform his operations in such a manner that boiling or other disturbances of the soil in the foundation area will be prevented. The Contractor shall keep the area being excavated dry by such means that water will be prevented from entering from the adjacent soils and adversely affecting the stability of the foundation material or supporting soils.

All dewatering and related earthwork shall be conducted in such a manner as to prevent siltation or contamination of the waterway.

The pumping discharge shall not be allowed to enter directly into the waterway nor onto the railroad tracks. The water from the work areas shall be pumped and discharged to an appropriate treatment or containment device (i.e. haybale corral/sediment filter bag) in accordance with applicable regulations. Specific means and methods of dewatering shall be

at the discretion of the Contractor. At no point in dewater process shall direct discharge be allowed into waterways.

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

Payment for all water control work, including the design and construction of the dewatering systems, all necessary equipment, materials and installation, pumping, sandbagging, earth, and other measures, all as outlined above, shall be included in the Contract Lump Sum Price for this item. No separate payment will be made for the removal and disposal of sediment material collected from the dewatering system; all costs in connection therewith shall be included in the Contract Lump Sum Price for this item.

Partial payment under this item will be as follows: The first payment of the Lump Sum bid price for this Item will be made upon completion of installation of the water control system to the satisfaction of the Engineer. The final payment of the Lump Sum bid price for this Item will be made upon the removal and satisfactory disposal of water control system from the project site at the completion of the work.

ITEM 995.01 BRIDGE STRUCTURE, BRIDGE NO. 77.04 LUMP SUM
ITEM 995.02 BRIDGE STRUCTURE, BRIDGE NO. 79.81 LUMP SUM

DESCRIPTION

A. The work specified under this section shall conform to the applicable provisions of Section 995 of the MassDOT Standard Specifications for Highways and Bridges, the Supplemental Specifications, and the specific requirements stipulated below for the component parts of these items. For those component parts where no specific requirement is stipulated, the Standard Specifications shall apply except for payment.

B. Work under this item shall include all materials, equipment and labor needed to construct the following:

- Bridge Excavation
- Steel Grating For Walkway
- Bridge Handrail
- Elastomeric Bridge Bearing Pads
- Structural Steel – Coated Steel
- Precast Concrete Abutment Caps
- Precast Concrete Pier Caps
- Prestressed Concrete Slabs
- Precast Concrete Wingwall Panels
- Precast Approach Slabs
- Structural Steel – Coated Steel
- Geotechnical Instrumentation
- Temporary Shoring
- Reinforced Concrete Protection for Pier Pile at Br. 77.04
- Wildlife Passage at Br. 79.81
- Cast-in-place Concrete Enclosures at Abutments of Br. 79.81

C. Contractor is responsible for providing an independent material testing company for concrete and dowel testing that is specified within the project documents. No separate payment for testing and shall be considered incidental to the work.

D. All field welders shall be certified by MassDOT and possess the Department's Welder Qualification Test Record and the Welder Qualification Certificate. All Welding Procedures shall be approved by the Engineer.

E. Cost for temporarily removal and reinstall ballast and track, temporary timber mats on bridges for construction phasing is incidental to Item 995.01 and 995.02.

F. The work does not include any items listed separately in the proposal. Payment for materials shown on the Plans as being part of these bridge structures or which may

be incidental to their construction and are not specifically included for payment under another item shall be considered incidental to the work performed under these items and shall be included in the unit price of the component of which they are a part.

BRIDGE EXCAVATION

Work should be performed in accordance with requirements under Item 140.0 in this special provisions.

STEEL GRATING FOR WALKWAY

GENERAL

These specifications apply to steel bar grating walkway as hereinafter defined and described. This work shall consist of furnishing and installing steel bar grating at the locations shown on the plans or as directed by the Engineer. Construction of the steel bar grating shall be done in accordance with this specification, the plans, and the manufacturer's instructions.

Work under these items is for furnishing and installation of steel grating walkways on Bridges 77.04 and 79.81.

The work under these items shall conform to the following standards:

1. The applicable provisions of Section 995 of the standard Specifications and the Supplemental Specifications.
2. The Contract Documents and Volume 2, Chapter 15 of the AREMA Manual for Railway Engineering, latest edition.
3. The specific requirements stipulated below for this item.

Work under this item shall include all material, equipment and labor needed to install steel grating walkways.

The work does not include any items listed separately in the proposal. Payment for materials shown on the Plans as being part of this bridge structure or which may be incidental to its construction and are not specifically included for payment under another item shall be considered incidental to the work performed under these items and shall be included in the unit price of the component of which they are a part.

REFERENCES

American National Standards Institute (ANSI)

MBG 531-09	Metal Bar Grating Manual

American Society for Testing and Materials (ASTM)

ASTM A 1011/A 1011M Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low- Alloy with Improved Formability, and Ultra-High Strength

ASTM A 510/A 510M Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel

DEFINITIONS

a. A metal bar grating is an open grid of metal bars. These bearing bars, which have a cross-sectional depth much greater than width, are held at regular spacing, usually parallel, either by:

   i. Straight, sinuous or corrugated cross bars having their longitudinal axis perpendicular to the bearing bars and being connected to them by welding, forging or mechanical locking, or by:

   ii. Bent connecting bars alternately contacting adjacent bearing bars and riveted to them at regular intervals.

b. Definitions of other terms shall conform to those given in the Glossary of Terms in MBG 531-09

MATERIALS

1. Steel Grating:

   a. Steel used in bearing bars, cross bars and connecting bars of rectangular section shall conform to ASTM A 1011/A 1011M commercial Steel (Type B) for hot rolled carbon steel sheet and strip.

   b. Cross bars made of wire rod shall conform to ASTM A 510/A 510M for carbon steel wire rods and coarse round wire, except that permissible tolerance on diameter of coarse round wire shall be ± 0.005 in. (± 0.13 mm).

   c. Combinations of ASTM A 1011/A 1011M and A 510/A 510M steels are permitted to be welded together.

   d. Rivets shall be of steel, ¼ in. (6 mm) minimum diameter, flat head type

   e. Finish shall be hot dip galvanized in accordance with ASTM A123 after fabrication

Suppliers of the steel grating which conform to the contract documents include, but are not limited to the following:

Manufacturer

Nucor Grating Fisher & Ludlow,
Inc. 1115 E 5000 N Road
Bourbonnais, IL 60914

Mc Nichols Co.
2 Home News Row
New Brunswick, NJ 08901-3602

Indiana gratings, Inc.
212 W. Douglas St.
Martinsville, IN 46151

or approved equal.

SUBMITTALS

The contractor shall submit 3 copies of catalog cuts or detailed shop drawings to the Engineer for review. Drawings shall clearly show all materials, finishes, and connection methods. No work shall commence prior to the approval of the Engineer.

All tolerances shall be within the limits shown on the Metal Bar Grating Manual.

Bandings, nosings, carriers and toe plates, when specified, shall be attached by welding as shown on page 20 of the Metal Bar Grating Manual.

All cutouts where more than one bearing bar is cut and bearing bars are not supported shall be load banded.

Unless specifically ordered otherwise, no welds anywhere shall be ground.

BRIDGE HANDRAIL

DESCRIPTION

1. CONTRACTOR: The CONTRACTOR shall furnish all labor, tools, equipment and material necessary for installation of BRIDGE HANDRAIL on Bridges 77.04 and 79.81 in accordance with the plans and as specified herein.

SUBMITTALS

1. Submittals: The CONTRACTOR shall prepare and deliver technical submittals for review and approval of the ENGINEER. All submittals must be approved before related work may begin. Listed below are submittals required for this item of work, additional submittals may be required due to site conditions or the nature of the work. In order to maintain correspondence records each submittal shall be assigned a submittal number and transmittal number for use by the CONTRACTOR and the ENGINEER. For additional information regarding each submittal refer to the appropriate section of this specification.
    a. Product data;
    b. Product specifications;
    c. Material Certifications;
    d. Plans showing location of handrail required with all necessary dimensions, and detail drawings showing standard handrail elevations, typical connections, anchoring systems, and expansion joints.
2. Shop Drawings: CONTRACTOR shall furnish one (1) complete electronic copy of detailed shop drawings for approval prior to starting fabrication. By approving and submitting shop drawings, the CONTRACTOR thereby represents that they have determined and verified all field measurements, field construction criteria, materials, catalog numbers and similar data, or will do so, and that they have checked and coordinated the shop drawings with the requirements of the work and of the contract documents.
3. Submittal Review: Approval by the ENGINEER is only for the purpose of confirming compliance with the contract plan and specifications. Approval shall not relieve the CONTRACTOR from responsibility for correctness, quantity and quality, nor for completeness of Work in accordance with the plans and specifications.

MATERIALS

1. Rails: ASTM A53/A53M, standard weight (Schedule 40), 2" nominal diameter pipe, galvanized.
2. Posts and Connection Plates: Structural steel ASTM A709, Grade 36, galvanized
3. U-Bolts: ASTM A307A galvanized ASTM A153.
4. Bolts: ASTM F3125, Grade A325 galvanized.
5. Galvanizing Repair Paint: High-zinc-dust-content paint for re-galvanizing welds in steel, complying with The Society for Protective Coating SSPC-Paint 20 or ASTM A780.

HANDLING AND STORING MATERIALS

1. Handling: All material shall be handled in a manner which will prevent members from being distorted or damaged. Stored material shall be piled securely, and no material shall be placed closer than 25 feet to the centerline of the nearest tracks. Material shall be placed on level platforms, skids, or other supports above the ground and shall be kept clean and properly drained.
2. Shipping: All materials shall be carefully loaded so as to avoid damage in transit. Members weighing more than 3 tons shall have the weight marked thereon. All small parts such as bolts, pins, washers, and small connection plates shall be packed in containers of adequate strength. The contents of each unit shall be plainly marked on the top of each container.

EXECUTION

1. Installation:
   a. Install in accordance with manufacturer's instructions.
   b. Install components plumb, straight and true, accurately fitted, free from distortion or defects.
   c. Assemble with mechanical fittings to accommodate tight joints and secure installation.
   d. At time approved by ENGINEER, remove protective wrap. Clean handrail with mild soap and water. Do not use solutions, steel wool, or abrasives.

ELASTOMERIC BRIDGE BEARING PAD

GENERAL

The work under this heading shall conform to the applicable provisions of Section M9.14.5 of the Standard Specifications and chapter 15 part 5.12 of the latest version of the AREMA Manual of Railway Engineering, and the Plans.

Bearings Pads shall meet Test Criteria I in accordance with Chapter 15 Part 5.12.9 of the AREMA Manual of Railway Engineering.

STRUCTURAL STEEL – COATED STEEL

GENERAL

The work under this item shall conform to section 960 of the Standard Specifications and the following.

Fabricated steel shall be galvanized as indicated on the plans. All fabrication shall be completed prior to surface preparation and the application of any coating.

The faying surfaces of all field bolted connections shall be coated based on the design of the

connection. Class B connections shall be masked prior to galvanizing to allow for application of an approved class B slip coefficient primer. After galvanizing the masked surface will be cleaned in accordance with SSPC-SP11 and coated with the approved zinc rich primer. A galvanized connection will result in a faying surface meeting a class C slip coefficient.

When grinding, drilling or any other operation produces steel turnings, filings, shavings, etc. the contractor shall completely clean all areas of all accumulation prior to the end of the work shift.

The Engineer shall provisionally accept the shop coated items before shipment to the jobsite but final acceptance of the coating system will occur after erection of the coated items, and after all required repairs and coating application has been completed.

The contractor shall be responsible for failure and damage of all applied coating. Failures include but are not limited to, visible corrosion, blistering, checking, cracking, or delamination (peeling) and loss of gloss and color of the coating system. Damage includes but is not limited to damage from installation or from external agents, such as scraping, vandalism, debris impacts, and collisions. The extent and method of repair must be approved by the Engineer.

PAINTING
The following items, as shown on the plans, shall be painted with one field coat of chemical mastic cm-15, etallic aluminum color, applied to a dry film thickness of 8 mils, corresponding to a wet film thickness of 10 mils. Paint application shall be in accordance with the manufacturers instructions.

1. Exposed portion of steel piles.
2. Exposed portions of PP pile plates, EP embedded plates, and BK brackets, and LRB longitudinal restraint brackets.

Paint shall be applied after the completion and acceptance of all field welding and assembly.

GALVANIZING
The following items, as shown in the plans, shall be hot dipped galvanized in accordance with Section M7 of these Specifications:

1. Deck plates
2. Cast-in inserts, nuts and washers.
3. Walkway Brackets, Railing Posts, Steel Grating Walkway, and Hand Railing

PRECAST CONCRETE BRIDGE ELEMENTS

A. General.

The work under this Heading consists of fabricating, transporting and installing the following:

- Precast Concrete Abument Caps
- Precast Concrete Pier Caps
- Precast Concrete Wingwall Panels
- Precast Approach Slabs

and includes all necessary labor, materials, and equipment to complete the work as shown on the Plans. The work shall conform with the MassDOT Standard, Supplemental, and Interim Specifications and the requirements of the current AASHTO LRFD Bridge Construction Specifications, supplemented by the current relevant provisions of the latest edition of PCI MNL-116 (The Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products), except as noted herein.

QUALITY ASSURANCE

A. General.

Quality Assurance includes all the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. It is an all-encompassing term that includes Quality Control (performed by the Fabricator) and Acceptance (performed by MassDOT). Quality Control is the system used by the Contractor and Fabricator to monitor and assess their production processes at the plant facility and installation activities at the project site to ensure that the final product will meet the specified level of quality. Acceptance includes all factors used by MassDOT to determine the corresponding value for the product. MassDOT Acceptance inspection at the plant facility is intended as a means of evaluation of compliance with contract requirements. Contractor and Fabricator Quality Control activities and MassDOT Acceptance activities shall remain independent from one another. MassDOT Acceptance activities shall not replace Fabricator Quality Control activities.

B. Fabricator Quality Control.

Quality Control shall be performed by the Fabricator to ensure that the product is fabricated in conformance with the specifications herein. The Fabricator shall maintain a Quality Control system to monitor, assess, and adjust placement and fabrication processes to ensure the Precast Concrete Bridge Element(s) meet the specified level of quality, through sufficient Quality Control sampling, testing, inspection, and corrective action (where required). The Fabricator's Quality Control system shall address all key activities during the placement and fabrication and shall be performed in conformance with the Fabricator's NPCA or PCI Certification. Quality Control documentation shall meet the requirements of the *Fabricator Quality Control – Documentation* section below. Upon request, Fabricator Quality Control documentation shall be provided to the MassDOT Plant Inspector.

1. Plant.

Prior to the fabrication of Precast Concrete Bridge Elements, the Fabricator's precast concrete plant shall obtain the following:

(a) Certification by the National Precast Concrete Association (NPCA) Plant Certification Program or Precast/Prestressed Concrete Institute (PCI) Plant Certification Program, for the applicable types of Precast Concrete Bridge Element(s) being fabricated
(b) MassDOT Prequalification
(c) MassDOT Mix Design Approval

All concrete for a given Precast Concrete Bridge Element shall be produced by a single company and plant, unless otherwise approved by the Engineer.

2. Personnel.
The Fabricator shall provide adequate training for all QC personnel in accordance with NPCA or PCI certification. There shall be sufficient personnel trained and certified to perform the tests listed under Subsection M4.02.13, Part D. At a minimum, the Fabricator's Quality Control Personnel shall maintain the following qualifications and certifications:

(a) QC Manager with an active NETTCP Field Technician or ACI Concrete Field Testing Technician – Grade I certification or higher, and a minimum of 4 years continuous experience in the manufacture of Precast Concrete Bridge Elements for state transportation departments. The QC Manager shall be on site while the batch plant is producing and placing concrete for MassDOT projects.
(b) A Technician/Inspector having the Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level I or NorthEast Transportation Training and Certification Program (NETTCP) Precast Concrete Inspector, or higher.

The Contractor shall submit to the Engineer a copy of the Fabricator's Quality Control Personnel required qualifications, as specified above.

3. Laboratory.
The Fabricator shall provide a room of sufficient size to house all equipment and to adequately perform all testing. The room shall have either a separate moisture storage room or curing box for concrete cylinders, and it shall be thermostatically controlled to maintain temperatures consistent with AASHTO T 23. It shall include a desk and file cabinet for proper record keeping, and have good lighting and ventilation. This room shall be kept for testing and quality control and not used for any other purpose. An additional desk and file cabinet shall be provided for exclusive use of the Engineer. No exception from these requirements will be allowed without the express written permission of the Engineer.

4. Testing Equipment.
At a minimum, the Fabricator's plant facility shall have the following testing equipment:

(a) Air Content Meter Type A or B: AASHTO T 152
(b) Air Content Meter Volumetric Method: AASHTO T 196 (Required for Lightweight Concrete)

(c) Slump Cone: AASHTO T 119
(d) Cylinder Molds AASHTO M 205
(e) Concrete Testing Machine: AASHTO T 22
(f) Screening Sieve: AASHTO T 27, AASHTO T 11
(g) Curing Box: AASHTO T 23
(h) Spread Test Base Plate for Self-Consolidating Concrete (SCC): ASTM C1611
(i) All other equipment prescribed by AASHTO and ASTM standards for the tests to be performed by the Fabricator as specified

5. Inspection.

Quality Control personnel shall monitor and inspect the fabrication of each Precast Concrete Bridge Element. Quality Control personnel shall report all inspection activities on Quality Control Inspection Reports and non-conformances on Non-Conformance Reports (NCRs) throughout the entire fabrication process, as speciefied herein.

6. Temperature Monitoring.

At a minimum, the Fabricator shall monitor, record, and report the temperatures of the form, ambient temperatures surrounding the concrete, and temperatures of the concrete continuously, without interruption as specified below:

(a) Prior to placement of concrete to verify that Ti ≥ 50°F.
(b) Immediately after placement to verify that T_i ≥ 50°F is maintained.
(c) Throughout the entire duration of the curing cycle, at regular intervals not to exceed one hour until 100% Design Strength (f'_c) is attained and concrete has cooled to within 40°F of the ambient temperature surrounding the Precast Concrete Bridge Element.

At a minimum, the temperature measuring devices shall record and report the temperature of the concrete to the nearest 2°F. At least two temperature sensors (thermocouples) shall be positioned to record the maximum and minimum anticipated concrete temperatures. The anticipated minimum temperature shall be measured with one or more thermocouples at a distance no greater than 2 inches from the surface of the thinnest section. The anticipated maximum temperature shall be measured with one or more thermocouples at the center of the thickest section. Proposed temperature measurement locations shall be submitted to the Engineer for approval. Temperature recording devices shall be located within the curing enclosure and calibrated as required by PCI MNL-116 Section 4.18.4. Maximum heat increase and cool down rates shall comply with PCI MNL-116, Section 4.19. The Contractor shall furnish temperature logs recorded at a minimum frequency of once per hour to the Inspector as required, with each post-pour QC inspection report.

7. Sampling and Testing.

At a minimum, the Fabricator shall perform random Quality Control sampling and testing as specified in *Table 1: Quality Control Sampling and Testing*. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been

retempered with admixtures or hold-back water during fabrication. Test Specimens shall conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60, with the exception of the Stripping (80% f'_c) set of cylinders. Stripping (80 % f'_c) cylinders shall be cured in the same location and environment as the Precast Bridge Elements they represent. If approved by the Engineer, compressive strength cylinder match curing equipment, that maintains the same concrete conditions that the corresponding Precast Bridge Element is exposed to, may be utilized in lieu of Stripping (80 % f'_c) field cured cylinders, with the use of thermocouples, controllers, and heaters.

Table 1: Quality Control Sampling and Testing

Quality Characteristic	Test Method	Sample Size	Specification Limit	Lot Size [(c)]	Sublot Size [(d)]	Frequency	Point of Sampling
Slump (in.) [(a)]	AASHTO T 119	Per AASHTO	≤ 8 in. or as approved by the Engineer	Total Quantity of Concrete (cy) produced on a Contract, per Type of Element fabricated, per Mix Design	20 cy	One (1) per Sublot or fraction thereof	Point of Discharge
Air Content (%)	AASHTO T 152	Per AASHTO	5% ≤ % ≤ 8%				
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F				
Compressive Strength (psi)	AASHTO T 22 AASHTO T 23	Stripping Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 80% f'_c at Stripping				
		7-day Cylinders: One (1) set of Three (3) 4 x 8 in.	For Information at 7 days				
		28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 28 days				
		56-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 56 days [(b)]				

Notes:

(a) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

(b) 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f' $_c$).
(c) Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
(d) Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

8. Certificate of Compliance.

The Fabricator shall provide a Certificate of Compliance in accordance with Standard Specifications, Division I, Section 6.01, stating that QC test cylinders have achieved the design strength, f'$_c$. A Certificate of Compliance shall accompany each shipment and shall be presented to the MassDOT Resident Engineer or designee upon delivery to the site.

9. Documentation.

At a minimum, the Fabricator shall maintain a filing system for the following QC records and documentation. All QC records and documentation shall be made available to MassDOT upon the request of the Department.

(a) Current MassDOT Approved Mix Design Sheet(s) and Approval Letter(s)
(b) PCI or NPCA Certification
(c) Current Qualifications and Certifications for QC Manager(s) and QC Technician(s)
(d) Most current set of Approved Shop Drawings
(e) Approved Placement, Finishing and Curing Plan
(f) Approved Dunnage Plan
(g) Fabricator Certificate of Compliance for each fabricated Precast Concrete Bridge Element
(h) Admixture Manufacturer's Certification of Compliance for each approved Admixture
(i) Completed QC Inspection Report for each fabricated Precast Concrete Bridge Element
(j) Identification Number for each fabricated Precast Concrete Bridge Element
(k) Time and date of casting of each fabricated Precast Concrete Bridge Element
(l) Date of stripping of each fabricated Precast Concrete Bridge Element
(m) Batch Ticket Printout reporting the quantity of concrete produced for each batch of concrete produced
(n) Concrete temperature records for each Precast Concrete Bridge Element fabricated
(o) QC Test Report Forms for each sublot of concrete produced
(p) Non-Conformance Reports (NCRs)
(q) Documentation of Repairs (if applicable)

C. Acceptance.

MassDOT will perform Acceptance inspection, sampling, and testing during fabrication and installation, to evaluate the quality and degree of compliance of the fabricated Precast Concrete Bridge Element to MassDOT specifications. Additionally, MassDOT Inspectors will monitor the Fabricator's Quality Control activities to ensure the Fabricator is properly

administering Quality Control in conformance with the Fabricator's NPCA or PCI Certification. Acceptance inspection and test results not meeting MassDOT specifications will result in Non-conformance Reports (NCR) being issued by MassDOT to the Fabricator or Contractor for corrective action. Final Acceptance for the fabricated Precast Concrete Bridge Elements shall be determined by MassDOT.

1. Inspection.

A MassDOT Inspector will be assigned to perform Acceptance activities during fabrication, which includes the inspection of the materials, work procedures, and Precast Concrete Bridge Elements. At least seven (7) days prior to the scheduled start of fabrication, the Fabricator shall contact the MassDOT Research and Materials Section (RMS) to provide notice of the scheduled fabrication start date. The Fabricator shall complete the following activites prior to notifying MassDOT RMS of the scheduled start date:

(a) Receive approval for all submitted Fabricator cement concrete mix designs from the MassDOT Research and Materials Section for the current year, as specified under the *Mix Design* section and *Table 3: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete shall meet the requirements of M4.02.17.
(b) Receive approval for the submitted Fabricator Placement, Finishing, and Curing Plan from the MassDOT Research and Materials Section, as specified under the *Placement, Finishing, and Curing Plan* section.
(c) Receive Engineer of Record approved shop drawings from the MassDOT Research and Materials Section as specified under the *Shop Drawings* section.
(d) Participate in the pre-production meeting, as described under the *Pre-Production Meeting* section (if required).

Prior to the start of fabrication, the Fabricator shall review the fabrication schedule with the MassDOT Inspector. Fabrication shall only proceed when:

(a) The QC Inspector and MassDOT Inspector are present to inspect the Precast Concrete Bridge Element(s) being fabricated.
(b) The QC Manager is present at the Fabricator's plant.

The Fabricator shall grant access to all required areas of the Fabricator's plant to the MassDOT Inspector, during the hours of fabrication. Fabrication without MassDOT Inspector access to required areas is prohibited, and will result in the rejection of the fabricated Precast Concrete Bridge Element(s).

Additionally, the MassDOT Inspector will monitor the adequacy of the Fabricator's Quality Control activities. MassDOT Inspector Acceptance activities performed at the Fabricator's plant shall remain independent from the Fabricator, and does not replace the Fabricator's required Quality Control activities.

2. Sampling and Testing.

At a minimum, the MassDOT Inspector will perform random Acceptance sampling and testing for each Sublot of concrete produced as specified in *Table 2: Acceptance Sampling and Testing.* The MassDOT Inspector will also perform Acceptance sampling and testing on concrete that has been retempered with admixtures or hold-back water during production. Test Specimens will conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60.

Table 2: Acceptance Sampling and Testing

Quality Characteristic	Test Method	Sample Size	Specification Limit	Lot Size [(c)]	Sublot Size [(d)]	Frequency	Point of Sampling
Slump (in.) [(a)]	AASHTO T 119	Per AASHTO	≤ 8 in. or as approved by the Engineer	Total Quantity of Concrete (cy) produced on a Contract, per Type of Element fabricated, per Mix Design	20 cy	One (1) per Sublot or fraction thereof	Point of Discharge
Air Content (%)	AASHTO T 152	Per AASHTO	5% ≤ % ≤ 8%				
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F				
Compressive Strength (psi)	AASHTO T 22 AASHTO T 23	7-day Cylinders: One (1) set of Three (3) 4 x 8 in.	For Information at 7 days				
		28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 28 days				
		56-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 56 days [(b)]				

Notes:

(a) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(b) 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f'_c).
(c) Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
(d) Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

MATERIALS

Materials shall meet the following specifications (if applicable):

General	M4.00.00
Portland Cement	M4.01.0
Blended Hydraulic Cements	M4.01.1
Fly Ash	M4.01.2
Cement Concrete	M4.02.00
Cement	M4.02.01
Cement Mortar	M4.02.15
Aggregates	M4.02.02
Lightweight Aggregates	M4.02.03
Water	M4.02.04
Cement Concrete Additives	M4.02.05
Proportioning	M4.02.06
Mixing and Delivery	M4.02.10
Test Specimens	M4.02.13
Mortar for Filling Keyways	M4.04.0
Slag	AASHTO M 302
High Performance Cement Concrete	M4.06.1
Self-Consolidating Concrete (SCC)	M4.02.17
Controlled Density Fill – Non-Excavatable	M4.08.0
Reinforcing Bars	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Galvanized Reinforcing Bars	M8.01.8
Welded Wire Reinforcement	M8.01.2
Mechanical Reinforcing Bar Splicer	M8.01.9
Lifting Devices	PCI MNL-116
Corrugated Metal Pipe	AASHTO M 36

1. Cement Concrete Mix Design.

The cement concrete shall be comprised of specified proportions of water and MassDOT approved aggregates, cement, supplementary cementitious materials (SCMs), and admixtures to form a homogenous composition. Cement concrete for Precast Concrete Bridge Elements shall meet the requirements of M4.06.1 High Performance Cement Concrete, with the exception that the "Total Cementitious Content" specified shall be considered the "Maximum Allowable Cementitious Content". When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

Prior to production of cement concrete, the Fabricator shall report and submit all proposed mix design formulations and its constituent materials onto the MassDOT Cement Concrete Mix Design Sheet to the MassDOT Research and Materials Section for review and approval. All mix design yields shall be designed for 1.0 cubic yards of concrete, with an allowable tolerance of +/- 1.0 %. All liquids incorporated into the proposed mix design(s) shall include both water and admixtures in the liquid mass calculation.

During production of cement concrete, the Fabricator shall not alter the previously approved mix design formulation or its constituent materials. Proposed alterations in source, type, batch quantity, or gradation to any of the constituent materials of the previously approved mix design formulation shall require a new MassDOT Mix Design Sheet submission to the MassDOT Research and materials Section for review and approval. Fabrication shall not occur without prior MassDOT mix design approval.

The Fabricator shall notify MassDOT RMS to schedule trial batch testing for the new mix design(s). Trial batch testing shall meet the following requirements:

(a) Performed by a qualified laboratory and/or AASHTO accredited laboratory.
(b) Performed and/or sampled in the presence of a MassDOT Inspector.
(c) Meet the requirements as specified in *Table 3: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete (SCC) shall meet M4.02.17.

Failure to perform all of the required trial batch testing or provide MassDOT RMS trial batch test results within the Specification Limits (as specified in Table 3) will result in the disqualification of the Fabricator's proposed mix design(s).

Table 3: Trial Batch Sampling and Testing for New Mix Designs

Quality Characteristic	Test Method	Sample Size	Specification Limit	Performed By
Slump (a)	AASHTO T 119	Per AASHTO	Max. 8 inches or as approved by the Engineer	Quality Control
Air Content (AC)	AASHTO T 152	Per AASHTO	5% ≤ AC ≤ 8%	Quality Control
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F	Quality Control
Compressive Strength (b)	AASHTO T 22 AASHTO T 23	28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	Lab Mixed $f'_{cr} = 1.3\ f'_c$ at 28 days Batch Mixed $f'_{cr} = 1.2\ f'_c$ at 28 days	MassDOT
Alkali-Silica Reaction (ASR) (d)	ASTM C 1567	Per ASTM	M4.02.00	Quality Control
Resistance to Chloride Ion Penetration Chloride Ion Penetration (e)	AASHTO T 358 (f)	28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	Resistivity ≥ 21 kΩ-cm at 28 days	MassDOT
Freeze/Thaw Durability (c)	AASHTO T 161 (Procedure A)	Per AASHTO	Relative Dynamic Modulus of Elasticity after 300 cycles ≥ 80%	Quality Control

Notes:

(a) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(b) Trial batch compressive strength testing shall be performed by MassDOT. Laboratory mixed trial batch compressive strength results shall achieve 130% Design Strength (f'_c). Batch-mixed trial batch compressive results shall achieve

120% f'c. Acceptance will be based on compressive strength testing performed by MassDOT.

(c) If an AASHTO accredited laboratory is preparing the trial batch test specimens, MassDOT Acceptance presence is not required. If the Fabricator is preparing the trial batch test specimens, MassDOT Acceptance presence is required during trial batch test specimen preparation.

(d) Alkali Silica Reaction (ASR) testing shall meet the requirements of M4.02.00. Independent laboratories performing ASR testing shall be listed on the MassDOT Quality Construction Materials List (QCML).

(e) Calcium nitrite shall be removed from mix designs containing the admixture and replaced by an equivalent quantity of water when preparing Chloride Ion Penetration resistance trial batch test specimens.

(f) The Wenner probe tip spacing "a" shall be 1.5.

2. Vertical Adjustment Assembly.

Vertical Adjustment Assembly details and material requirements shall be as shown on the plans. Alternate devices may be used provided that they are adjustable and can support the anticipated loads. The design of the leveling devices, with necessary calculations, shall be submitted to the Engineer of Record for approval.

3. Grout.

Grout used for shear keys, vertical adjustment assembly voids, and hand holes shall be in accordance with M4.04.0.

4. Reinforcement.

All reinforcing steel shall be coated Grade 60 unless otherwise noted on the plans. Mechanical reinforcing bar splicers shall be epoxy coated.

5. Threaded Inserts.

Threaded inserts are permissible to facilitate forming the keyway pours. Threaded inserts shall be hot dip galvanized or made of stainless steel. The number of threaded inserts shall be minimized, and the inserts shall not come in contact with the reinforcing steel.

6. Corrugated Metal Pipe.

Corrugated Metal Pipe to be used for forming voids as specified on the plans shall be fabricated from steel and shall have a protective metallic coating of zinc (galvanizing).

CONSTRUCTION METHODS – PLANT FABRICATION

A. Shop Drawings.

Prior to performing any work under this Section, the Contractor shall receive approval for all shop drawings for the Precast Concrete Bridge Element being worked on and any special Contract requirements, provided that a complete shop drawing package is provided. The Contractor shall not order materials or begin work before receiving approved shop drawings. MassDOT will reject Precast Concrete Bridge Elements that deviate from the

approved drawings or are fabricated prior to receiving written approval of the shop drawings. The Contractor shall bear full responsibility and costs for all materials ordered or work performed prior to the approval of the shop drawings or written authorization from MassDOT.

Contractor shall submit scaled shop drawings to the Engineer of Record for review and approval. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24x36") paper copies of the Approved (or Approved As Noted) shop drawings to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. An approval stamp shall appear on every shop drawing sheet. Wet-stamping or wet-signing is not required, provided that the stamp and reviewer name are legible. The Fabricator's name and address shall appear on each sheet.

Resubmittal of "Approved as Noted" shop drawings is not necessary for minor revisions, provided that the correction can be clearly understood and is unambiguous without possibility of misinterpretation. Shop drawings with questions or comments that require a response and/or additional information from the Fabricator must be resubmitted.

Detailed shop drawings shall be prepared in accordance with the relevant provisions of Subsection 5.02 and shall, at a minimum, contain the following:

(a) Number and type and/or piece mark of the precast concrete bridge element including overall length, width and height.
(b) Skew angle.
(c) Location, size and geometry of all steel reinforcement, including mechanical reinforcing bar splicers to be used for connecting Precast Concrete Bridge Elements together in the field.
(d) Location and details of all inserts, anchors, Vertical Adjustment Assemblies, and any other items required to be cast into the Precast Concrete Bridge Elements (whether detailed on the plans by the Engineer of Record or provided for the Contractor's convenience). Precast Concrete Bridge Elements shall not be fired or drilled into for attachment purposes. All hardware shall be galvanized except as noted.
(e) Locations and details of the lifting devices, including supporting calculations, type and amount of any additional reinforcing required for lifting. The Fabricator shall design all lifting devices based on the no cracking criteria in Chapter 8 of the PCI Design Handbook (7th edition).
(f) The minimum compressive strength required prior to handling the precast concrete bridge element.

The shop drawings shall not include procedures for placement, finishing, and curing of concrete. These details shall be included in the Placement, Finishing and Curing Plan that is to be submitted to MassDOT Research and Materials Section as described under *Placement, Finishing, and Curing Plan*.

B. Fabrication.

All Precast Concrete Bridge Elements shall be fabricated in accordance with the latest edition of PCI MNL-116 as modified herein.

C. Placement, Finishing and Curing Plan.

At least 30 days prior to start of fabrication, the Contractor shall submit the Fabricator's proposed Placement, Finishing and Curing Plan to the Engineer for approval by MassDOT Research and Materials Section. This shall be an independent submittal, separate from the fabrication shop drawings. The Placement, Finishing and Curing Plan shall include the following:

(a) Method of Mixing
(b) Method of Placement
(c) Method of Consolidation
(d) Method of Finishing
(e) Method of Initial Curing
(f) Method of Intermediate Curing
(g) Method of Final Curing
(h) Moisture Retention Materials and Equipment (water spray equipment, saturated covers, sheet materials, liquid membrane-forming compounds, accelerated curing equipment, etc.)
(i) Cylinder Curing Methods, Location, and Environmental Control (temperature, humidity, etc.)
(j) Temperature Monitoring, Recording, and Reporting

D. Dunnage Plan Shop Drawings.

At least 30 days prior to the start of fabrication, the Contractor shall submit proposed Dunnage Plan Shop Drawings to the Engineer of Record for review and approval. This shall be an independent submittal, separate from the fabrication shop drawings. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24"x36") paper copies of the Approved (or Approved As Noted) Dunnage Plan to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. The Dunnage Plan shall include the following:

(a) Proposed layout of the Precast Concrete Bridge Elements for storage in yard and during shipping
(b) Support and blocking point locations
(c) Support and blocking materials

E. Pre-Production Meeting.

The Contractor shall notify the MassDOT Research and Materials Section to determine if a pre-production meeting will be required to review the specification, shop drawings, curing plan, schedule, and discuss any specific requirements. The meeting shall be held prior to scheduling a MassDOT Inspector (refer to Section *Quality Assurance – Precast Concrete, C. Acceptance, A. Inspection*), and at least seven (7) days prior to the scheduled

casting of any Precast Concrete Bridge Element or control section. The Contractor shall schedule the meeting, which shall include representatives of the Fabricator and MassDOT.

F. Reinforcement.

The reinforcing bars shall be installed in accordance with Section 901.62 of the Supplemental Specifications, including tolerances for cover and horizontal spacing of bars. Components of mechanical reinforcing bar splicers shall be set with the tolerances shown on the plans. The reinforcing bars and mechanical reinforcing bar splicers shall be assembled into a rigid cage that will maintain its shape in the form and which will not allow individual reinforcing bars to move during the placement of concrete. This cage shall be secured in the form so that the clearances to all faces of the concrete, as shown on the plans, shall be maintained.

Where reinforcing bars are to protrude from one Precast Concrete Bridge Element in order to mate with reinforcing bar splicers in a second precast concrete element, the fabricator shall set the reinforcing bars and the reinforcing bar splicers with a template in order to ensure proper fit up within the tolerances specified on the plans.

G. Tolerances.

Tolerances for steel reinforcement placement shall be in accordance with 901.62. Tolerances for precast concrete elements shall comply with the latest version of the PCI MNL 135, Precast Tolerance Manual.

H. Forms.

Concrete shall be cast in rigidly constructed forms, which will maintain the Precast Concrete Bridge Elements within specified tolerances to the shapes, lines and dimensions shown on the approved fabrication drawings. Forms shall be constructed from flat, smooth, non-absorbent material and shall be sufficiently tight to prevent the leakage of the plastic concrete. When wood forms are used, all faces in contact with the concrete shall be laminated or coated with a non-absorbent material. All worn or damaged forms, which cause irregularities on the concrete surface or damage to the concrete during form removal, shall be repaired or replaced before being reused. Any defects or damage of more than “Category 2, Minor Defects” made to the concrete, due to form work, stripping or handling, shall be subject to repair or rejection, as defined in the *Repairs and Replacement* section. If threaded inserts are cast into the elements for support of formwork, the inserts shall be recessed a minimum of 1 inch and shall be plugged after use with a grout of the same color as that of the precast cement concrete.

I. Mixing of Concrete.

The concrete shall be proportioned and mixed in conformance with the Fabricator’s MassDOT approved mix design and M4.02.10 Mixing and Delivery Fabrication shall not occur without prior MassDOT mix design approval. The Fabricator shall provide copies of batch tickets to the MassDOT Plant Inspector. The MassDOT Plant Inspector will verify if the batch ticket quantities are within the tolerances of the Fabricator’s MassDOT approved mix design.

J. Placement of Concrete.

Prior to the placement of concrete, the temperature of the forms shall be greater than or equal to 50°F. Quality Control inspection shall be performed by the Fabricator as specified in the *Fabricator Quality Control* section. Placement of the concrete shall not proceed until the MassDOT Plant Inspector is present to perform inspection and begin monitoring Fabricator Quality Control inspection activities, and is in compliance with specifications. The MassDOT Plant Inspector shall inspect and accept the placement of the reinforcing steel prior to the placement of concrete into the forms. The Fabricator shall verify all materials and equipment required for protecting and curing the concrete are readily available and meet the requirements of the *Final Curing Methods* section below. All items encased in the concrete shall be accurately placed in the position shown on the Plans and firmly held during the placing and setting of the concrete. Clearance from the forms shall be maintained by supports, spacers, or hangers and shall be of approved shape and dimension.

During placement, the concrete shall maintain a concrete temperature range between 50°F and 90°F. The Fabricator shall minimize the time to concrete placement (measured from start of mixing to completion of placement). In no event shall time to placement exceed 90 minutes. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during the placement of the concrete as specified in the *Fabricator Quality Control* section above. Delays or shutdowns of over 30 minutes shall not be allowed during the continuous filling of individual forms.

K. Consolidation of Concrete.

Suitable means shall be used for placing concrete to prevent segregation or displacement of reinforcing steel or forms. The concrete shall be thoroughly consolidated by external or internal vibrators or a combination of both. Vibrators shall not be used to move concrete within the forms. Vibrators shall be used as specified in 901.63C and as directed by the Engineer. Concrete shall be placed and consolidated in a way that minimizes the presence of surface voids or bug holes on the formed surfaces. When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

L. Finishing of Concrete.

The top of the prestressed concrete beams shall be given a float finish except for those areas that will have concrete cast against them, which shall receive a rake finish with a ¼" amplitude applied longitudinally along the length of the beam to the limits shown on the plans.

M. Exposed Surfaces of Precast Concrete Bridge Elements.

As soon as conditions permit, before the concrete has fully hardened, all dirt, laitance, and loose aggregate shall be removed from the exposed concrete surfaces. Contractor shall not allow foot traffic on the uncured concrete until it has reached sufficient strength to prevent damage.

N. Exposed Surfaces of Closure Pour Shear Keys.

The closure pour shear key cast in the sides of the beam flanges shall have an exposed aggregate finish. The closure pour reinforcing steel and its coating shall not be damaged by the process for creating the exposed aggregate surface. Fabricator may utilize a surface retarder with water blast, abrasive blast, or a combination of both to achieve the desired shear key finish. The abrasive blast shall use oil free compressed air. The profile of the shear key surfaces shall be similar to that of 60 grit sand paper.

O. Initial Curing Methods.

After the placement of concrete and prior to concrete finishing, the Fabricator shall initiate initial curing methods when the concrete surface begins to dry, to reduce moisture loss from the surface. Application of one or more of the following initial curing methods shall occur immediately after the bleed water sheen has disappeared.

1. Fogging.

Fogging nozzles shall atomize water into a fog-like mist. The fog spray shall be directed and remain visibly suspended above the concrete surface, to increase the humidity of the air and reduce the rate of evaporation. Water from fogging shall not be worked into the surface during finishing operations and shall be removed or allowed to evaporate prior to finishing.

2. Liquid-applied Evaporation Reducers

Evaporation reducers shall be sprayed onto the freshly placed concrete surface to produce an effective monomolecular film that reduces the risk of plastic-shrinkage cracking and rate of evaporation of the bleed water from the concrete surface. Evaporation reducers shall be applied in accordance with manufacturer’s recommendations.

P. Intermediate Curing Methods.

The Fabricator shall initiate intermediate curing methods if concrete finishing has taken place prior to the concrete reaching final set. The freshly finished concrete surface shall be protected from moisture loss, by the continuation of initial curing methods (fogging and evaporation reducers) until final curing methods are applied or by the use of liquid membrane-forming curing compounds (see *Liquid Membrane-Forming Compounds for Curing* section).

Q. Final Curing Methods.

The Fabricator shall initiate and apply final curing methods to the concrete immediately after the following conditions are met:

(a) Completion of concrete finishing
(b) Final set of concrete
(c) Concrete has hardened sufficiently enough to prevent surface damage

During fabrication of Precast Concrete Bridge Elements, the Fabricator shall maintain the required concrete temperature ranges throughout the entire duration of the final curing

method cycle as specified herein. Controlled and gradual termination of the final curing method shall occur after all specified conditions are met. The concrete temperature shall be reduced at a rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the final curing method enclosure. The Fabricator shall maintain a minimum concrete temperature of 40°F until 100% f'c is attained (see *Handling and Storage* section below).

1. Water Spray Curing.

All exposed concrete surfaces shall remain moist with a continuous fine spray of water throughout the entire duration of the final curing method cycle (see *Table 4: Final Curing Method Cycle for Water Spray*).

Table 4: Final Curing Method Cycle for Water Spray

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Five (5) days	≥ 80% f'_c

2. Saturated Covers for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of saturated covers throughout the entire duration of the final curing method cycle (see *Table 5: Final Curing Method Cycle for Saturated Covers*). Saturated covers shall be allowed to dry thoroughly before removal to provide uniform, slow drying of the concrete surface.

Table 5: Final Curing Method Cycle for Saturated Covers

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Three (3) days	≥ 80% f'_c

Saturated covers, such as burlap, cotton mats, and other coverings of absorbent materials shall meet the requirements of AASHTO M 182, Class 3. Saturated covers shall be in good condition, free from holes, tears, or other defects that would render it unsuitable for curing concrete. Saturated covers shall be dried to prevent mildew when storing. Prior to application, saturated covers shall be thoroughly rinsed in water and free of harmful substances that are deleterious or cause discoloration to the concrete. Saturated covers shall have sufficient thickness and proper positioning onto the concrete surface to maximize moisture retention.

Saturated covers shall contain a sufficient amount of moisture to prevent moisture loss from the surface of the concrete. Saturated covers shall be kept continuously moist so that a film of water remains on the concrete surface throughout the entire duration of the final curing method cycle. The Fabricator shall not permit the saturated covers to dry and absorb water from the concrete. Use of polyethylene film (see *Polyethylene Film* section) may be applied over the saturated cover to potentially decrease the need for continuous watering.

3. Sheet Materials for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of curing sheet materials throughout the entire duration of the final curing method cycle (see *Table 6: Final Curing Method Cycle for Curing Sheet Materials*).

Table 6: Final Curing Method Cycle for Sheet Materials

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Three (3) days	≥ 80% f'_c

Sheet Materials used for curing, such as polyethylene film, white burlap-polyethylene sheeting, and reinforced paper shall meet the requirements of ASTM C171 and the specifications herein. Sheet materials shall inhibit moisture loss and reduce temperature rise in concrete exposed to radiation from the sun during the final curing method cycle. Adjoining covers shall overlap not less than 12 inches. All edges of the covers shall be secured to maintain a moist environment.

(a) Polyethylene Film.

Polyethylene film shall meet the requirements of ASTM C171, consist of a single sheet manufactured from polyethylene resins, be free of visible defects, and have a uniform appearance. Careful considerations shall be taken by the Fabricator to prevent the film from tearing during storage and application, so as to not disrupt the continuity of the film (polyethylene film reinforced with glass or other fibers is more durable and less likely to be torn). The Fabricator shall monitor the application of the film to prevent uneven spots from appearing (mottling) on the concrete surface, due to variations in temperature, moisture content, or both. The Fabricator shall prevent mottling from occurring on the concrete surface by applying additional water under the film or applying a combination of polyethylene film bonded to absorbent fabric to the concrete surface to retain and evenly distribute the moisture.

Immediately following final finishing, polyethylene film shall be placed over the surface of the fresh concrete surface, so as to not damage the surface of the concrete and shall be placed and weighted so that it remains in contact with the concrete throughout the entire duration of the final curing method cycle. The film shall extend beyond the edges of the concrete surface. The film shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling. Edges of adjacent polyethylene film shall overlap a minimum of 6 inches and be tightly sealed with the use of sand, wood planks, pressure-sensitive tape, mastic, or glue to maintain close contact with the concrete surface, retain moisture, and prevent the formation of air pockets throughout the entire duration of the final curing method cycle.

(b) White Burlap-Polyethylene Sheeting

White burlap-polyethylene sheeting shall meet the requirements of ASTM C171, be securely bonded to the burlap so to avoid separation of the materials during handling and curing of the concrete, and be applied in the same manner as the polyethylene film.

(c) Reinforced Impervious Paper.

Reinforced impervious paper shall meet the requirements of ASTM C171, consist of two sheets of kraft paper cemented together with a bituminous adhesive and reinforced with embedded cords or strands of fiber running in both directions, and be white in color. Reinforced impervious paper shall be treated to prevent tearing when wetted and dried.

Reinforced impervious paper can be reused so long as it is effective in retaining moisture on the concrete surface. The Fabricator shall visually inspect the reinforced impervious paper for all holes, tears, and pin holes from deterioration of the paper through repeated use by holding the paper up to the light. The paper shall be discarded and prohibited from use when the moisture is no longer retained.

After the concrete has hardened sufficiently to prevent surface damage, the concrete surface shall be thoroughly wetted prior to the application of the reinforced impervious paper, and be applied in the same manner as the polyethylene film.

4. Liquid Membrane-Forming Compounds for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of liquid membrane-forming compounds throughout the entire duration of the final curing method cycle (see *Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds*).

Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Seven (7) days	≥ 80% f'_c

Liquid membrane-forming compounds shall meet the requirements of ASTM C 1315, Type I, Class A and shall exhibit specific properties, such as alkali resistance, acid resistance, adhesion-promoting quality, and resistance to degradation by ultraviolet light, in addition to moisture-retention capabilities. Liquid membrane-forming compounds shall consist of waxes, resins, chlorinated rubber, or other materials to reduce evaporation of moisture from concrete. Liquid membrane-forming compounds shall be applied in accordance with the manufacturer’s recommendations.

Liquid membrane-forming compounds shall be applied immediately after the disappearance of the surface water sheen following final finishing. All exposed surfaces shall be wetted immediately after form removal and kept moist to prevent absorption of the compound, allowing the curing membrane to remain on the concrete surface for proper membrane moisture retention. The concrete shall reach a uniformly damp appearance with no free water on the surface prior to the application of the compound.

If patching or finishing repairs are to be performed prior to the application of the compound, the Precast Concrete Bridge Element shall be covered temporarily with

saturated covers until the repairs are completed and the compound is applied. Only areas being repaired shall be uncovered during this period. While the saturated covers are removed to facilitate the patching process, the work shall continue uninterrupted. If for any reason the work is interrupted, saturated covers shall be placed onto the uncovered concrete surface, until the work continues and is completed, at which time the curing compound shall be applied to the repaired area.

Careful considerations shall be made by the Fabricator to determine if the evaporation rate is exceeding the rate of bleeding, thus causing the surface to appear dry even though bleeding is still occurring. Under such conditions, the application of liquid membrane-forming compounds to the concrete surface shall be delayed, in order to prevent bleed water from being sealed below the concrete surface and avert map cracking of the membrane films, reduction in moisture-retention capability, and reapplication of the compound. To diagnose and prevent this condition, the Fabricator shall place a transparent plastic sheet over a test area of the uncured and unfinished concrete surface and shall determine if any bleed water accumulates under the plastic.

The compound shall be applied in two applications at right angles to each other to ensure uniform and more complete coverage. On very deeply textured surfaces, the surface area to be treated shall be at least twice the surface area of a troweled or floated surface. In such cases, two separate applications may be needed, each at 200 ft^2/gal., with the first being allowed to become tacky before the second is applied.

The curing compound shall be applied by power sprayer, using appropriate wands and nozzles with pressures between 25 and 100 psi. For very small areas such as repairs, the compound shall be applied with a wide, soft-bristled brush or paint roller. The compound shall be stirred or agitated before use and applied uniformly in accordance with the manufacturer’s recommended rate. The Fabricator shall verify the application rates are in accordance with the manufacturer’s recommended rate.

When the concrete surface is to receive paint, finishes, or toppings that require positive bond to the concrete, it is critical that the curing procedures and subsequent coatings, finishes, or toppings be compatible to achieve the necessary bond

After the termination of the final curing method cycle has occured, liquid membrane-forming compounds shall be removed by blast-cleaning from any concrete surface that is to receive paint, finishes, plastic concrete from secondary pour, grout, or any other toppings that require bonding to the concrete surface. These surfaces shall be further blast-cleaned to remove the cement matrix down to exposed aggregate to ensure proper bonding to the material. The method used to remove the curing compound shall not damage the reinforcement and coating. Compounds are prohibited on any concrete surface that will have a penetrating or coating type treatment such as a sealer, stain, or waterproofing membrane applied to it.

5. Accelerated Curing.

Accelerated curing shall use live steam or radiant heat with moisture in accordance with PCI MNL-116 as modified herein. The concrete temperature shall meet the maximum heat increase and cool down rates as specified herein. Concrete temperature monitoring shall meet the requirements of the *Temperature Monitoring* section. Excessive and fluctuating rates of heating and cooling shall be prohibited. The concrete temperature shall not exceed

158°F at any time. The Fabricator shall meet the following accelerated curing sequencing and requirements.

(a) Initial Delay Period.

The initial delay period shall be defined as the duration immediately following the placement of the concrete and the attainment of initial set of the concrete. The Fabricator shall determine the time of initial set in accordance with AASHTO T 197 specifications. Throughout the entire duration of the preset period, initial curing shall be implemented. The temperature increase period (see *Temperature Increase Period* section) shall not occur until initial set of the concrete is attained. During the initial delay period, the concrete temperature shall meet the following requirements:

i. Concrete temperature rate of increase shall not exceed 10°F per hour.
ii. Total concrete temperature increase shall not exceed 40°F higher than the placement concrete temperature or 100°F, whichever is less

(b) Temperature Increase Period.

The temperature increase period shall be defined as the duration immediately following the completion of the initial delay period (after initial set) and immediately prior to the start of the constant maximum temperature period. Application of steam to the enclosure shall not occur until the initial delay period is complete. After the initial delay period is complete, all exposed concrete surfaces shall be cured in a moist environment where the concrete temperature increases at a rate not to exceed 36°F per hour.

(c) Constant Maximum Temperature Period.

The constant maximum temperature period shall be defined as the duration immediately following the completion of the temperature increase period and immediately prior to the start of the temperature decrease period. After the temperature increase period is complete, all exposed concrete surfaces shall be cured in a moist environment at a controlled and constant elevated temperature throughout the entire duration of the constant maximum temperature period. Termination of the constant maximum temperature period and the start of the termination decrease period shall occur after all specified conditions are met (see *Table 8: Constant Maximum Temperature Period*).

Table 8: Constant Maximum Temperature Period

Sustained Concrete Temperature	Constant Maximum Temperature Period	Compressive Strength
120°F ≤ °F ≤ 158°F	6 hrs ≤ Time ≤ 48 hrs	≥ 80% f'_c

(d) Temperature Decrease Period.

After the constant maximum temperature period is complete, the concrete temperature shall be cured in a moist environment at a controlled and reduced rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of

the curing enclosure.

R. Stripping.

The Fabricator shall not strip forms or handle the Precast Concrete Bridge Element until Quality Control compressive strength cylinders attain a minimum compressive strength of 80% Design Strength (f'_c) or the value indicated on the approved drawings has been achieved. After removal from the form, all exposed concrete surfaces shall continue to be cured in conformance with the *Final Curing Methods* sections until completion.

S. Handling and Storage of Precast Concrete Bridge Elements.

Precast Concrete Bridge Elements may be exposed to temperatures below freezing (32°F) when the chosen curing cycle has been completed, provided that the following conditions are met:

(a) Precast Concrete Bridge Elements are protected from precipitation with polyethylene curing covers until 100% f'_c is attained
(b) Precast Concrete Bridge Elements maintain a minimum concrete temperature of 40°F until 100% f'_c is attained

Precast Concrete Bridge Elements damaged during handling and storage will be repaired or replaced at MassDOT's direction at no cost to MassDOT. Precast Concrete Bridge Elements shall be lifted at the designated points by approved lifting devices embedded in the concrete and in accordance with proper lifting and handling procedures. Storage areas shall be smooth and well compacted to prevent damage due to differential settlement. Precast Concrete Bridge Elements shall be supported on the ground by means of continuous blocking, in accordance with the approved dunnage plan.

Precast Concrete Bridge Elements shall be loaded on a trailer with blocking as described above, in accordance with the approved dunnage plan. Shock-absorbing cushioning material shall be used at all bearing points during transportation of the Precast Concrete Bridge Elements. Blocking shall be provided at all locations of tie-down straps. Precast Concrete Bridge Elements stored prior to shipment shall be inspected by the Contractor prior to being delivered to the site to identify damage that would be cause for repair or rejection.

T. Repairs and Replacement.

In the event defects are identified, they shall be classified in the following categories and a non-conformance report (NCR) shall be filed if required. The NCR shall be submitted to MassDOT for review. Defects in all categories shall be documented by plant Quality Control personnel and made available to MassDOT upon request. Any required repairs shall utilize materials listed on the MassDOT QCML.

Where noted, defects shall be repaired according to the PCI Northeast Region Guidelines for Resolution of Non-Conformances in Precast Concrete Bridge Elements, Report Number PCINE-18-RNPCBE. Please note that reference to PCINE-18-RNPCBE is made for repair details only. In the case of conflicts with this Special Provision, this Special Provision shall govern.

1. Category 1, Surface Defects.

Category 1 defects do not need to be repaired, and an NCR does not need to be filed. Surface defects are defined as the following:

(a) Surface voids or bug holes that are less than 5/8-inch in diameter and less than ¼-inch deep, except when classified as Category 4
(b) Cracks less than or equal to 0.006 inches wide
(c) Cracks less than or equal to 0.125 inches wide on surfaces that will receive a field-cast concrete overlay

2. Category 2, Minor Defects.

Category 2 defects shall be repaired, but an NCR does not need to be filed. Minor defects are defined as the following:

(a) Spalls, honeycombing, surface voids that are less than 2 inches deep and have no dimension greater than 12 inches
(b) Cracks less than or equal to 0.016 inches that will not receive a concrete overlay
(c) Broken or spalled corners that will be covered by field-cast concrete

Minor defects shall be repaired according to PCINE-18-RNPCBE. Cracks shall be sealed according to the PCI Repair Procedure #14 in PCINE-18-RNPCBE.

3. Category 3, Major Defects.

For Category 3 defects, the Fabricator shall prepare an NCR that documents the defect and describes the proposed repair procedure. The NCR shall be submitted to MassDOT for approval prior to performing the repair. Major defects are defined as the following:

(a) Spalls, honeycombing and surface voids that are deeper than 2 inches or have any dimension greater than 12 inches, when measured along a straight line
(b) Concentrated area of defects consisting of four or more Category 2 Defects within a 4-square foot area.
(c) Exposed reinforcing steel
(d) Cracks greater than 0.016 inches and less than or equal to 0.060 inches in width that will not receive a concrete overlay
(e) Bearing area spalls with dimensions not exceeding 3 inches
(f) Cracks, spalls and honeycombing that will be encased in cast in place concrete need not be repaired, but the limits and location of the defects shall be documented with an NCR

Upon MassDOT approval, defects and cracks shall be repaired according to PCINE-18-RNPCBE and this specification. All repairs shall be completed at the expense of the Contractor.

4. Category 4, Rejectable Defects.

Rejectable defects as determined by the MassDOT Inspector, RMS, and Engineer may be cause for rejection. Fabricator may submit an NCR with a proposed repair procedure, requesting approval. Some rejectable defects are defined as the following:

(a) Surface defects on more than 5% of the surface area which will be exposed to view after installation
(b) Minor defects that in total make up more than 5% of the surface area of the unit
(c) Cracks greater than 0.060 inches in width except as noted in Category 1
(d) Elements fabricated outside of the specified tolerances
(e) MassDOT compressive strength testing that does not meet the specified Design Strength, f'_c

U. Loading.

Prior to the Fabricator loading the Precast Bridge Element on to the truck for shipping, the Fabricator shall provide the MassDOT Plant Inspector and RMS a minimum seven (7) days' notice of the Fabricator's intent to load the Precast Bridge Element. Inspection by the MassDOT Plant Inspector shall take place while the element is still on dunnage in the yard. The element shall not be loaded onto the truck until the MassDOT Plant Inspector has performed the inspection.

V. Shipping.

Prior to shipment, the Fabricator shall perform the following actions and provide the required documentation to the MassDOT Plant Inspector:

(a) Precast Concrete Bridge Elements shall remain at the Fabricator's plant for a minimum of 7 days after cast date.
(b) QC Inspection Reports shall be signed by the Quality Control Manager and provided to the MassDOT Plant Inspector.
(c) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative Sublot shall be generated by the Fabricator and provided to the MassDOT Plant Inspector.
(d) Certificate of Compliance shall be generated by the Fabricator as described under the Fabricator Quality Control section and provided to the MassDOT Plant Inspector.
(e) All MassDOT RMS approved Corrective Actions submitted on the Non-Conformance Reports (NCR), shall be verified to have been completed by the MassDOT Plant Inspector and Quality Control Manager.
(f) All NCRs shall be signed off by the Quality Control Manager, MassDOT Inspector and MassDOT RMS.

W. Delivery.

Upon Delivery, the following documentation shall be provided to the MassDOT Resident Engineer or designee:

(a) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative sublot.
(b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(c) QC Inspection Reports signed by the Quality Control Manager.

The Contractor shall inspect Precast Concrete Bridge Elements upon receipt at the site. Precast Concrete Bridge Elements damaged during delivery shall be repaired or replaced at MassDOT's direction at no cost to MassDOT.

CONSTRUCTION METHODS – FIELD CONSTRUCTION

A. General.

All of the Contractor's field personnel involved in the erection and assembly of the Precast Concrete Bridge Elements shall have knowledge of and follow the approved Erection Procedure.

Prior to installation, the following documentation shall be reviewed and confirmed by the MassDOT Resident Engineer or designee:

(a) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Precast Concrete Bridge Element's representative sublot.
(b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(c) QC Inspection Reports signed by the Quality Control Manager.

Field construction staff shall verify that the Resident Engineer has accepted all Precast Concrete Bridge Elements prior to installation.

B. Erection Procedure.

Prior to the erection, the Contractor shall submit an Erection Procedure for approval by the Engineer. This submittal shall include computations and drawings for the transport, hoisting, erection and handling of the Precast Concrete Bridge Elements. The Erection Procedure shall be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts with working knowledge of the Contractor's equipment, approved shop drawings, and materials to build the bridge. The Erection Procedure shall, at a minimum, include the following:

1. Erection Procedure

The Erection Procedure shall be prepared to conform to the requirements of 960.61, Erection and the applicable sections in Chapter 8 of the PCI Design Handbook (seventh edition) for handling, erection, and bracing requirements. At a minimum, the Erection Procedure shall provide:

(a) Minimum concrete compressive strength for handling the Precast Concrete Bridge Elements.
(b) Concrete stresses during handling, transport, and erection.
(c) Crane capacities, pick radii, sling geometry, and lifting hardware.
(d) Verification that the equipment can handle all pick loads and weights with the required factor of safety.
(e) Evaluation of construction sequence and evaluation of any geometric conflicts in the lifting of the Precast Concrete Bridge Elements and setting them as shown on the plans.
(f) Design of crane supports including verification of subgrade for support.
(g) Location and design of all temporary bracing that will be required during erection.

Non-shrink grout and concrete materials, approved by the Engineer, shall be placed as shown on the plans. Fill joints, keyways, and voids, in strict accordance with the specifications and manufacturer's recommendations and instructions.

For footings, approach slabs and highway guardrail transitions, once these Precast Concrete Bridge Elements have been set to the correct horizontal and vertical alignment, the void between them and the supporting soil shall be filled with Controlled Density Fill – Non-Excavatable to the limits as shown on the plans. Add additional grout ports in the footings to facilitate the bedding process if required.

Joints shall be filled flush to the top with non-shrink grout, and any vertical misalignment between adjacent elements shall be feathered out on a slope of 1 to 12.

Curing of grout or concrete shall be performed in strict accordance with the specifications and manufacturer's recommendations. Filling shall not be completed in cold weather when either the ambient temperature or the precast member's temperature is below the manufacturer's recommendation. No localized heating of either the precast members or of the air surrounding the element will be permitted in an attempt to reach application temperatures.

If the joints or voids are not filled within five days after the Precast Bridge Elements are erected, the Contractor shall cover and protect the openings from weather and debris until they are filled.

C. Field Welding

Field welding of embedded plates to driven piles and lateral restraint brackets shall be per Section 960 of the Standard Specifications.

D. Survey and Layout.

Working points, working lines, and benchmark elevations shall be established prior to placement of all elements. The Contractor is responsible for field survey as necessary to complete the work. MassDOT reserves the right to perform additional independent survey. If discrepancies are found, the Contractor may be required to verify previous survey data.

E. Preparation of Closure Pour Keyways.

Immediately prior to erecting the Precast Concrete Bridge Elements, the closure pour shear keys shall be cleaned at the job site of all dust, dirt, carbonation, laitance, and other

potentially detrimental materials which may interfere with the bonding of the closure pour concrete and precast concrete using a high-pressure water blast. The exposed reinforcing steel in the precast concrete shall be protected from damage during the cleaning of the keyways. Damaged epoxy coating of steel reinforcement shall be repaired, and the reinforcing steel shall be cleaned as directed by the Engineer. The surfaces of the shear keys shall be wetted so that the surfaces shall have a Saturated Surface Dry (SSD) condition for at least 24 hours prior to the placement of the closure pour concrete.

F. Erection.

The elements shall be placed in the sequence and according to the methods outlined in the Erection Procedure. As the erection proceeds, the Contractor shall constantly monitor the assembly to ensure that the precast concrete bridge element is within proper horizontal and vertical location and tolerances prior to releasing it from the crane and setting the next unit. The Contractor may use shims to maintain proper setting tolerances.

The concrete elements shall be lifted only by the lifting devices, and the utmost care shall be taken to prevent distortion of the elements during handling, transportation or storage.

Suitable spreaders shall be used during lifting so that only a vertical pull will be made on the lifting device. A non-vertical lifting force may be permitted if prior written approval is given by the Engineer. This approval will be contingent on the Contractor demonstrating by calculations, prepared by a Professional Engineer registered in Massachusetts, that the elements will not be damaged by the non-vertical lifting force and by documentation that the capacity of the lifting devices is adequate for the non-vertical lifting force.

Precast components shall be pre-bed with non-shrink grout thicker than shim stacks prior to placing other precast elements on top of them.

After all Precast Concrete Bridge Elements have been placed, the actual overall dimensions of the structure both horizontal and vertical, as laid out shall not deviate from the nominal dimensions shown on the plans beyond a tolerance of +0 inches and -1 inches. Once the layout of Precast Concrete Bridge Elements has been accepted by the Engineer, the Contractor shall cut all lifting devices off below the surfaces of the elements.

G. Application of Mastic Field Coating

Mastic Field coating shall be applied only after pile welding has been accepted by the engineer.

H. Filling of Blockouts for Lifting Devices and Threaded inserts.

If the blockouts in the Precast Concrete Bridge Elements where the lifting devices were located will be exposed and visible after assembly is complete, the Contractor shall fill these blockouts with Cement Mortar (M4.02.15) or grout.

After the formwork has been removed, all threaded inserts that have been cast into the precast concrete bridge deck for support of the formwork shall be filled with a grout of the same color as that of the precast concrete.

<u>PRESTRESSED CONCRETE SLABS</u>

A. General.

The work under this Heading consists of fabricating, transporting and installing the following:

- Prestressed Concrete Slabs

and includes all necessary labor, materials, and equipment to complete the work as shown on the Plans. The work shall conform to the MassDOT Standard Specifications and the requirements of the current AASHTO LRFD Bridge Construction Specifications, supplemented by the current relevant provisions of the latest edition of PCI MNL-116 (The Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products), except as noted herein. MassDOT contract documents shall take precedence over the AASHTO LRFD Bridge Construction Specifications and PCI MNL-116. Section 930, M4.02.14, and M4.03.00 through M4.03.14 of the MassDOT Standard Specifications are superseded in their entirety by the requirements specified below.

QUALITY ASSURANCE

A. General.

Quality Assurance includes all the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. It is an all-encompassing term that includes Quality Control (performed by the Fabricator) and Acceptance (performed by MassDOT). Quality Control is the system used by the Contractor and Fabricator to monitor and assess their production processes at the plant facility and installation activities at the project site to ensure that the final product will meet the specified level of quality. Acceptance includes all factors used by MassDOT to determine the corresponding value for the product. MassDOT Acceptance inspection at the plant facility is intended as a means of evaluation of compliance with contract requirements. Contractor and Fabricator Quality Control activities and MassDOT Acceptance activities shall remain independent from one another. MassDOT Acceptance activities shall not replace Fabricator Quality Control activities.

B. Fabricator Quality Control.

Quality Control shall be performed by the Fabricator to ensure that the product is fabricated in conformance with the specifications herein. The Fabricator shall maintain a Quality Control system to monitor, assess, and adjust placement and fabrication processes to ensure the Prestressed Concrete Beam(s) meet the specified level of quality, through sufficient Quality Control sampling, testing, inspection, and corrective action (where required). The Fabricator's Quality Control system shall address all key activities during the placement and fabrication and shall be performed in conformance with the Fabricator's PCI Certification. Quality Control documentation shall meet the requirements of the *Fabricator Quality Control – Documentation* section below. Upon request, Fabricator Quality Control documentation shall be provided to the MassDOT Plant Inspector.

1. Plant.

Prior to the fabrication of Prestressed Concrete Beams, the Fabricator's precast concrete plant shall obtain the following:

(d) Certification by the Precast/Prestressed Concrete Institute (PCI) Plant Certification Program, for Prestressed Concrete Beam fabrication, Category B3 level or higher
(e) MassDOT Prequalification
(f) MassDOT Mix Design Approval

All concrete for a given Prestressed Concrete Beam shall be produced by a single company and plant, unless otherwise approved by the Engineer.

2. Personnel.

The Fabricator shall provide adequate training for all QC personnel in accordance with PCI certification. There shall be sufficient personnel trained and certified to perform the tests listed under Subsection M4.02.13, Part D. At a minimum, the Fabricator's Quality Control Personnel shall maintain the following qualifications and certifications:

(c) QC Manager with an active Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level II or higher, and a minimum of 5 years continuous experience in the manufacture of Prestressed Concrete Beams for state transportation departments. The QC Manager shall be on site while the batch plant is producing and placing concrete for MassDOT projects.
(d) A Technician/Inspector having the Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level II or higher

The Contractor shall submit to the Engineer a copy of the Fabricator's Quality Control Personnel required qualifications, as specified above.

3. Laboratory.

The Fabricator shall provide a room of sufficient size to house all equipment and to adequately perform all testing. The room shall have either a separate moisture storage room or curing box for concrete cylinders, and it shall be thermostatically controlled to maintain temperatures consistent with AASHTO T 23. It shall include a desk and file cabinet for proper record keeping, and have good lighting and ventilation. This room shall be kept for testing and quality control and not used for any other purpose. An additional desk and file cabinet shall be provided for exclusive use of the Engineer. No exception from these requirements will be allowed without the express written permission of the Engineer.

4. Testing Equipment.

At a minimum, the Fabricator's plant facility shall have the following testing equipment:

(j) Air Content Meter Type A or B: AASHTO T 152
(k) Air Content Meter Volumetric Method: AASHTO T 196 (Required for Lightweight Concrete)
(l) Slump Cone: AASHTO T 119
(m) Cylinder Molds AASHTO M 205

(n) Concrete Testing Machine: AASHTO T 22
(o) Screening Sieve: AASHTO T 27, AASHTO T 11
(p) Curing Box: AASHTO T 23
(q) Spread Test Base Plate for Self-Consolidating Concrete (SCC): ASTM C1611
(r) All other equipment prescribed by AASHTO and ASTM standards for the tests to be performed by the Fabricator as specified

5. Inspection.

Quality Control personnel shall monitor and inspect the fabrication of each Prestressed Concrete Beam. Quality Control personnel shall report all inspection activities on Quality Control Inspection Reports and non-conformances on Non-Conformance Reports (NCRs) throughout the entire fabrication process, as speciefied herein.

6. Temperature Monitoring.

At a minimum, the Fabricator shall monitor, record, and report the temperatures of the form, ambient temperatures surrounding the concrete, and temperatures of the concrete continuously, without interruption as specified below:

(d) Prior to placement of concrete to verify that Ti ≥ 50°F.
(e) Immediately after placement to verify that T_i ≥ 50°F is maintained.
(f) Throughout the entire duration of the curing cycle, at regular intervals not to exceed one hour until 100% Design Strength (f'_c) is attained and concrete has cooled to within 40°F of the ambient temperature surrounding the Prestressed Concrete Beam.

At a minimum, the temperature measuring devices shall record and report the temperature of the concrete to the nearest 2°F. At least two temperature sensors (thermocouples) shall be positioned to record the maximum and minimum anticipated concrete temperatures. The anticipated minimum temperature shall be measured with one or more thermocouples at a distance no greater than 2 inches from the surface of the thinnest section. The anticipated maximum temperature shall be measured with one or more thermocouples at the center of the thickest section. Proposed temperature measurement locations shall be submitted to the Engineer for approval. Temperature recording devices shall be located within the curing enclosure and calibrated as required by PCI MNL-116 Section 4.18.4. Maximum heat increase and cool down rates shall comply with PCI MNL-116, Section 4.19. The Contractor shall furnish temperature logs recorded at a minimum frequency of once per hour to the Inspector as required, with each post-pour QC inspection report.

7. Sampling and Testing.

At a minimum, the Fabricator shall perform random Quality Control sampling and testing as specified in *Table 1: Quality Control Sampling and Testing*. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during fabrication. Test Specimens shall conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60, with the exception of the Stripping (80%

f'_c) set of cylinders. Stripping (80% f'_c) cylinders shall be cured in the same location and environment as the Prestressed Concrete Beam they represent. If approved by the Engineer, compressive strength cylinder match curing equipment, that maintains the same concrete conditions that the corresponding Prestressed Concrete Beam is exposed to, may be utilized in lieu of Stripping (80% f'_c) field cured cylinders, with the use of thermocouples, controllers, and heaters.

Table 1: Quality Control Sampling and Testing

Quality Characteristic	Test Method	Sample Size	Specification Limit	Lot Size [c]	Sublot Size [d]	Frequency	Point of Sampling
Slump (in.) [a]	AASHTO T 119	Per AASHTO	≤ 8 in. or as approved by the Engineer	Total Quantity of Beams fabricated on a Contract, per Bid Item, per Mix Design	One (1) Beam	One (1) per Sublot or fraction thereof	Point of Discharge
Air Content (%)	AASHTO T 152	Per AASHTO	5% ≤ % ≤ 8%				
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F				
Compressive Strength (psi)	AASHTO T 22 AASHTO T 23	Stripping Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 80% f'_c at Stripping				
		7-day Cylinders: One (1) set of Three (3) 4 x 8 in.	For Information at 7 days				
		28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 28 days				
		56-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 56 days [b]				

Notes:

(e) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(f) 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f'_c).

(g) Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
(h) Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

8. Certificate of Compliance.

The Fabricator shall provide a Certificate of Compliance in accordance with Standard Specifications, Division I, Section 6.01, stating that QC test cylinders have achieved the design strength, f'_c. A Certificate of Compliance shall accompany each shipment and shall be presented to the MassDOT Resident Engineer or designee upon delivery to the site.

9. Documentation.

At a minimum, the Fabricator shall maintain a filing system for the following QC records and documentation. All QC records and documentation shall be made available to MassDOT upon the request of the Department.

(r) Current MassDOT Approved Mix Design Sheet(s) and Approval Letter(s)
(s) PCI Certification
(t) Current Qualifications and Certifications for QC Manager(s) and QC Technician(s)
(u) Most current set of Approved Shop Drawings
(v) Approved Placement, Finishing and Curing Plan
(w) Approved Dunnage Plan
(x) Fabricator Certificate of Compliance for each fabricated Prestressed Concrete Beam
(y) Admixture Manufacturer's Certification of Compliance for each approved Admixture
(z) Completed QC Inspection Report for each fabricated Prestressed Concrete Beam
(aa) Identification Number for each fabricated Prestressed Concrete Beam
(bb) Time and date of casting of each fabricated Prestressed Concrete Beam
(cc) Date of stripping of each fabricated Prestressed Concrete Beam
(dd) Batch Ticket Printout reporting the quantity of concrete produced for each batch of concrete produced
(ee) Concrete temperature records for each fabricated Prestressed Concrete Beam
(ff) QC Test Report Forms for each sublot of concrete produced
(gg) Non-Conformance Reports (NCRs)
(hh) Documentation of Repairs (if applicable)

C. Acceptance.

MassDOT will perform Acceptance inspection, sampling, and testing during fabrication and installation, to evaluate the quality and degree of compliance of the fabricated Prestressed Concrete Beam to MassDOT specifications. Additionally, MassDOT Inspectors will monitor the Fabricator's Quality Control activities to ensure the Fabricator is properly administering Quality Control in conformance with the Fabricator's NPCA or PCI Certification. Acceptance inspection and test results not meeting MassDOT specifications will result in Non-conformance Reports (NCR) being issued by MassDOT to the Fabricator

or Contractor for corrective action. Final Acceptance for the fabricated Prestressed Concrete Beams shall be determined by MassDOT.

1. Inspection.

A MassDOT MassDOT Inspector will be assigned to perform Acceptance activities during fabrication, which includes the inspection of the materials, work procedures, and Prestressed Concrete Beams. At least seven (7) days prior to the scheduled start of fabrication, the Fabricator shall contact the MassDOT Research and Materials Section (RMS) to provide notice of the scheduled fabrication start date. The Fabricator shall complete the following activites prior to notifying MassDOT RMS of the scheduled start date:

(e) Receive approval for all submitted Fabricator cement concrete mix designs from the MassDOT Research and Materials Section for the current year, as specified under the *Mix Design* section and *Table 3: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete shall meet the requirements of M4.02.17.
(f) Receive approval for the submitted Fabricator Placement, Finishing, and Curing Plan from the MassDOT Research and Materials Section, as specified under the *Placement, Finishing, and Curing Plan* section.
(g) Receive Engineer of Record approved shop drawings from the MassDOT Research and Materials Section as specified under the *Shop Drawings* section.
(h) Participate in the pre-production meeting, as described under the *Pre-Production Meeting* section (if required).

Prior to the start of fabrication, the Fabricator shall review the fabrication schedule with the MassDOT Inspector. Fabrication shall only proceed when:

(c) The QC Inspector and MassDOT Inspector are present to inspect the Prestressed Concrete Beam(s) being fabricated.
(d) The QC Manager is present at the Fabricator's plant.

The Fabricator shall grant access to all required areas of the Fabricator's plant to the MassDOT Inspector, during the hours of fabrication. Fabrication without MassDOT Inspector access to required areas is prohibited, and will result in the rejection of the Prestressed Concrete Beam(s).

Additionally, the MassDOT Inspector will monitor the adequacy of the Fabricator's Quality Control activities. MassDOT Inspector Acceptance activities performed at the Fabricator's plant shall remain independent from the Fabricator, and does not replace the Fabricator's required Quality Control activities.

2. Sampling and Testing.

At a minimum, the MassDOT Inspector will perform random Acceptance sampling and testing for each Sublot of concrete produced as specified in *Table 2: Acceptance Sampling and Testing.* The MassDOT Inspector will also perform Acceptance sampling and testing on concrete that has been retempered with admixtures or hold-back water during

production. Test Specimens will conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60.

Table 2: Acceptance Sampling and Testing

Quality Characteristic	Test Method	Sample Size	Specification Limit	Lot Size [c]	Sublot Size [d]	Frequency	Point of Sampling
Slump (in.) [a]	AASHTO T 119	Per AASHTO	≤ 8 in. or as approved by the Engineer	Total Quantity of Beams fabricated on a Contract, per Bid Item, per Mix Design	One (1) Beam	One (1) per Sublot or fraction thereof	Point of Discharge
Air Content (%)	AASHTO T 152	Per AASHTO	5% ≤ % ≤ 8%				
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F				
Compressive Strength (psi)	AASHTO T 22 AASHTO T 23	7-day Cylinders: One (1) set of Three (3) 4 x 8 in.	For Information at 7 days				
		28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 28 days				
		56-day Cylinders: One (1) set of Three (3) 4 x 8 in.	≥ 100% f'_c at 56 days [b]				

Notes:

(e) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(f) 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f'_c).
(g) Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
(h) Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

<u>MATERIALS</u>

Materials shall meet the following specifications (if applicable):

General	M4.00.00
Portland Cement	M4.01.0

Blended Hydraulic Cements	M4.01.1
Fly Ash	M4.01.2
Cement Concrete	M4.02.00
Cement	M4.02.01
Cement Mortar	M4.02.15
Aggregates	M4.02.02
Lightweight Aggregates	M4.02.03
Water	M4.02.04
Cement Concrete Additives	M4.02.05
Proportioning	M4.02.06
Mixing and Delivery	M4.02.10
Test Specimens	M4.02.13
Mortar for Filling Keyways	M4.04.0
Slag	AASHTO M 302
High Performance Cement Concrete	M4.06.1
Self-Consolidating Concrete (SCC)	M4.02.17
Prestressing Strands	AASHTO M 203
Reinforcing Bars	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Welded Wire Reinforcement	M8.01.2
Mechanical Reinforcing Bar Splicer	M8.01.9
Strand Chuck	M8.15.0
Lifting Devices	PCI MNL-116

1. Cement Concrete Mix Design.

The cement concrete shall be comprised of specified proportions of water and MassDOT approved aggregates, cement, supplementary cementitious materials (SCMs), and admixtures to form a homogenous composition. When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

The Fabricator is responsible for developing the concrete mix to be used for fabricating prestressed beams and having it prequalified by the MassDOT Research and Materials Section. The mix design compressive strength shall be as shown on the plans and as prequalified by the MassDOT Research and Materials Section. Prequalification shall include the trial batch testing shown in Table 3. For previously prequalified mixes, the Fabricator shall perform any tests specified in Table 3 that were not previously performed.

If the concrete mix has not been prequalified by the MassDOT Research and Materials Section, the Fabricator shall design and submit for approval, the proportions and test results for a concrete mix that shall attain the requirements specified in Table 3. The proposed mix design and all required test results shall be submitted to the MassDOT Research and Materials Section for approval. Requirements for additional testing and receipt of additional documentation from the Fabricator will be determined by RMS. Unsatisfactory results or other conditions identified during this additional testing and additional documentation review, will require re-submission of a new mix design for review and approval.

The mix shall be formulated with calcium nitrite corrosion inhibitors, which shall be added at a rate of 3 gallons per cubic yard of concrete in order to increase the active

corrosion threshold to 9.9 pounds of chloride per cubic yard of concrete at the reinforcing bar level.Prior to production of cement concrete, the Fabricator shall report and submit all proposed mix design formulations and its constituent materials onto the MassDOT Cement Concrete Mix Design Sheet to the MassDOT Research and Materials Section for review and approval. All mix design yields shall be designed for 1.0 cubic yards of concrete, with an allowable tolerance of +/- 1.0 %. All liquids incorporated into the proposed mix design(s) shall include both water and admixtures in the liquid mass calculation.

During production of cement concrete, the Fabricator shall not alter the previously approved mix design formulation or its constituent materials. Proposed alterations in source, type, batch quantity, or gradation to any of the constituent materials of the previously approved mix design formulation shall require a new MassDOT Mix Design Sheet submission to the MassDOT Research and materials Section for review and approval. Fabrication shall not occur without prior MassDOT mix design approval. All concrete used for prestressed concrete beams shall be batched by the Fabricator producing the prestressed concrete beams. The use of ready-mix concrete batched by others shall not be permitted.

The Fabricator shall notify MassDOT RMS to schedule trial batch testing for the new mix design(s). Trial batch testing shall meet the following requirements:

(d) Performed by a qualified laboratory and/or AASHTO accredited laboratory.
(e) Performed and/or sampled in the presence of a MassDOT Inspector.
(f) Meet the requirements as specified in *Table 3: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete (SCC) shall meet M4.02.17.

Failure to perform all of the required trial batch testing or provide MassDOT RMS trial batch test results within the Specification Limits (as specified in Table 3) will result in the disqualification of the Fabricator’s proposed mix design(s).

Table 3: Trial Batch Sampling and Testing for New Mix Designs

Quality Characteristic	Test Method	Sample Size	Specification Limit	Performed By
Slump [a]	AASHTO T 119	Per AASHTO	Max. 8 inches or as approved by the Engineer	Quality Control
Air Content (AC)	AASHTO T 152	Per AASHTO	5% ≤ AC ≤ 8%	Quality Control
Temperature (°F)	AASHTO T 309	Per AASHTO	50°F ≤ °F ≤ 90°F	Quality Control
Compressive Strength [b]	AASHTO T 22 AASHTO T 23	28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	Lab Mixed $f'_{cr} = 1.3 f'_c$ at 28 days Batch Mixed $f'_{cr} = 1.2 f'_c$ at 28 days	MassDOT
Alkali-Silica Reaction (ASR) [d]	ASTM C 1567	Per ASTM	M4.02.00	Quality Control
Resistance to Chloride Ion Penetration Chloride Ion Penetration [e]	AASHTO T 358 [f]	28-day Cylinders: One (1) set of Three (3) 4 x 8 in.	Resistivity ≥ 21 kΩ-cm at 28 days	MassDOT

Freeze/Thaw Durability [c]	AASHTO T 161 (Procedure A)	Per AASHTO	Relative Dynamic Modulus of Elasticity after 300 cycles $\geq$ 80%	Quality Control

Notes:

(a) Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
(b) Trial batch compressive strength testing shall be performed by MassDOT. Acceptance will be based on compressive strength testing performed by MassDOT. For mixes requiring f'_c > 8,000 psi, three consecutive trial batches shall be performed, all achieving $f'_{cr} \geq 1.1\ f'_c$, for MassDOT approval.
(c) If an AASHTO accredited laboratory is preparing the trial batch test specimens, MassDOT Acceptance presence is not required. If the Fabricator is preparing the trial batch test specimens, MassDOT Acceptance presence is required during trial batch test specimen preparation.
(d) Alkali Silica Reaction (ASR) testing shall meet the requirements of M4.02.00. Independent laboratories performing ASR testing shall be listed on the MassDOT Quality Construction Materials List (QCML).
(e) Calcium nitrite shall be removed from mix designs containing the admixture and replaced by an equivalent quantity of water when preparing Chloride Ion Penetration resistance trial batch test specimens.
(f) The Wenner probe tip spacing “a” shall be 1.5.

2. Reinforcement and Prestressing Strands.
The size and grade of steel reinforcement and prestressing strands shall be as indicated on the plans. All reinforcing steel shall be epoxy coated, Grade 60. All prestressing strands shall be uncoated.

3. Threaded Inserts
Threaded inserts are permissible in Prestressed Concrete Beams for installing formwork, utility supports, or deck drains. Threaded inserts shall be hot dip galvanized or made of stainless steeland shall not come in contact with the reinforcing steel. The number of threaded inserts installed for the Contractor’s convenience shall be kept to a minimum.

CONSTRUCTION METHODS – PLANT FABRICATION

A. Shop Drawings

Prior to performing any work under this Section, the Contractor shall receive approval for all shop drawings for the Prestressed Concrete Beam being worked on and any special Contract requirements, provided that a complete shop drawing package is provided. The Contractor shall not order materials or begin work before receiving approved shop drawings. MassDOT will reject any precast concrete bridge decks that deviate from the approved drawings or are fabricated prior to receiving written approval of the shop drawings. The Contractor shall bear full responsibility and costs for all materials ordered or

work performed prior to the approval of the shop drawings or written authorization from MassDOT.

The Contractor shall submit scaled shop drawings to the Engineer of Record for review and approval. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24x36") paper copies of the Approved (or Approved As Noted) shop drawings to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. An approval stamp shall appear on every shop drawing sheet. Wet-stamping or wet-signing is not required, provided that the stamp and reviewer name are legible. The Fabricator's name and address shall appear on each sheet.

Resubmittal of "Approved as Noted" shop drawings is not necessary for minor revisions, provided that the correction can be clearly understood and is unambiguous without possibility of misinterpretation. Shop drawings with questions or comments that require a response and/or additional information from the Fabricator must be resubmitted.

Detailed shop drawings shall be prepared in accordance with the relevant provisions of Subsection 5.02 and shall, at a minimum, contain the following:

(g) Number and type of Prestressed Concrete Beams including overall length, width and height.
(h) Skew angle.
(i) Location and spacing of strands, draped strands and their geometry, and/or location and spacing of strands to be debonded including the length of each strand's debondment.
(j) Location, size and geometry of all steel reinforcement, and mechanical reinforcing bar splicers if called for on the plans.
(k) Location and details of all inserts, anchors, and any other items required to be cast into the Prestressed Concrete Beams (whether detailed on the plans by the Engineer of Record or provided for the Contractor's convenience). Prestressed Concrete Beams shall not be fired or drilled into for attachment purposes. All hardware shall be galvanized except as noted.
(l) Locations and details of the lifting devices, including supporting calculations, type and amount of any additional reinforcing required for lifting. The Fabricator shall design all lifting devices based on the no cracking criteria in Chapter 8 of the PCI Design Handbook (7^{th} edition).
(m) The minimum compressive strength required prior to release of prestressing and prior to handling the Prestressed Concrete Beam.

The shop drawings shall not include procedures for placement, finishing, and curing of concrete. These details shall be included in the Placement, Finishing and Curing Plan that is to be submitted to MassDOT Research and Materials Section as described under *Placement, Finishing, and Curing Plan*.

B. Fabrication.

All Prestressed Concrete Beams shall be fabricated in accordance with the latest edition of PCI MNL-116 as modified herein.

C. Placement, Finishing and Curing Plan.

At least 30 days prior to start of fabrication, the Contractor shall submit the Fabricator's proposed Placement, Finishing and Curing Plan to the Engineer for approval by MassDOT Research and Materials Section. This shall be an independent submittal, separate from the fabrication shop drawings. The Placement, Finishing and Curing Plan shall include the following:

(k) Method of Mixing
(l) Method of Placement
(m) Method of Consolidation
(n) Method of Finishing
(o) Method of Initial Curing
(p) Method of Intermediate Curing
(q) Method of Final Curing
(r) Moisture Retention Materials and Equipment (water spray equipment, saturated covers, sheet materials, liquid membrane-forming compounds, accelerated curing equipment, etc.)
(s) Cylinder Curing Methods, Location, and Environmental Control (temperature, humidity, etc.)
(t) Temperature Monitoring, Recording, and Reporting

D. Dunnage Plan Shop Drawings.

At least 30 days prior to the start of fabrication, the Contractor shall submit proposed Dunnage Plan Shop Drawings to the Engineer of Record for review and approval. This shall be an independent submittal, separate from the fabrication shop drawings. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24"x36") paper copies of the Approved (or Approved As Noted) Dunnage Plan Shop Drawings to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. The Dunnage Plan Shop Drawings shall include the following:

(d) Proposed layout of the Prestressed Concrete Beams for storage in yard and during shipping
(e) Support and blocking point locations
(f) Support and blocking materials

E. Pre-Production Meeting.

The Contractor shall notify the MassDOT Research and Materials Section to determine if a pre-production meeting will be required to review the specification, shop drawings, curing plan, schedule, and discuss any specific requirements. The meeting shall be held prior to scheduling a MassDOT Inspector (refer to Section *Quality Assurance – Precast Concrete*, *C. Acceptance*, *A. Inspection*), and at least seven (7) days prior to the scheduled casting of any Prestressed Concrete Beam or control section. The Contractor shall schedule the meeting, which shall include representatives of the Fabricator and MassDOT.

F. Reinforcement.

The reinforcing bars shall be installed in accordance with Section 901.62 of the Supplemental Specifications, including tolerances for cover and horizontal spacing of bars. Components of mechanical reinforcing bar splicers shall be set with the tolerances shown on the plans. The reinforcing bars and mechanical reinforcing bar splicers shall be assembled into a rigid cage that will maintain its shape in the form and which will not allow individual reinforcing bars to move during the placement of concrete. This cage shall be secured in the form so that the clearances to all faces of the concrete, as shown on the plans, shall be maintained.

G. Placing and Tensioning Strands.

Placing and tensioning strands shall be in accordance with PCI MNL-116. The location of all prestressing strands shall be as indicated on the plans.

H. Tolerances.

Fabrication shall comply with tolerances specified on the plans. Tolerances for steel reinforcement placement shall be in accordance with 901.62. In the absence of specifications on the plans, tolerances shall comply with the latest version of the PCI MNL 135, Precast Tolerance Manual.

I. Forms.

Concrete shall be cast in rigidly constructed forms, which will maintain the Prestressed Concrete Beams within specified tolerances to the shapes, lines and dimensions shown on the approved fabrication drawings. Forms shall be constructed from flat, smooth, non-absorbent material and shall be sufficiently tight to prevent the leakage of the plastic concrete. When wood forms are used, all faces in contact with the concrete shall be laminated or coated with a non-absorbent material. All worn or damaged forms, which cause irregularities on the concrete surface or damage to the concrete during form removal, shall be repaired or replaced before being reused. Any defects or damage of more than “Category 2, Minor Defects” made to the concrete, due to form work, stripping or handling, shall be subject to repair or rejection, as defined in the *Repairs and Replacement* section. If threaded inserts are cast into the elements for support of formwork, the inserts shall be recessed a minimum of 1 inch and shall be plugged after use with a grout of the same color as that of the precast cement concrete.

Where applicable, the material used for forming voids in concrete deck beams and box beams shall be sufficiently strong and resistant to water to support the wet concrete, which is to be packed around the void forms, without collapsing. The void forms shall be securely anchored so that no movement will occur during placing and consolidation of the concrete. Void drains shall be installed at the locations shown on the plans and Fabricator shall ensure that the drains are in contact with the void form. After the beams have been cast and removed from the forms, the Fabricator shall check that the drains are still in contact with the void form by inserting a rigid probe into the drain for a distance greater than the thickness of the concrete at the void drain.

J. Mixing of Concrete.

The concrete shall be proportioned and mixed in conformance with the Fabricator's MassDOT approved mix design and M4.02.10 Mixing and Delivery. Fabrication shall not occur without prior MassDOT mix design approval. The Fabricator shall provide copies of batch tickets to the MassDOT Plant Inspector. The MassDOT Plant Inspector will verify if the batch ticket quantities are within the tolerances of the Fabricator's MassDOT approved mix design.

K. Placement of Concrete.

Prior to the placement of concrete, the temperature of the forms shall be greater than or equal to 50°F. Quality Control inspection shall be performed by the Fabricator as specified in the *Fabricator Quality Control* section. Placement of the concrete shall not proceed until the MassDOT Plant Inspector is present to perform inspection and begin monitoring Fabricator Quality Control inspection activities and is in compliance with specifications. The MassDOT Plant Inspector shall inspect and accept the placement of the reinforcing steel and prestressing strands prior to the placement of concrete into the forms. The Fabricator shall verify all materials and equipment required for protecting and curing the concrete are readily available and meet the requirements of the *Final Curing Methods* section below. All items encased in the concrete shall be accurately placed in the position shown on the Plans and firmly held during the placing and setting of the concrete. Clearance from the forms shall be maintained by supports, spacers, or hangers and shall be of approved shape and dimension.

During placement, the concrete shall maintain a concrete temperature range between 50°F and 90°F. The Fabricator shall minimize the time to concrete placement (measured from start of mixing to completion of placement). In no event shall time to placement exceed 90 minutes. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during the placement of the concrete as specified in the *Fabricator Quality Control* section above. Delays or shutdowns of over 30 minutes shall not be allowed during the continuous filling of individual forms.

L. Consolidation of Concrete.

Suitable means shall be used for placing concrete to prevent segregation or displacement of reinforcing steel or forms. The concrete shall be thoroughly consolidated by external or internal vibrators or a combination of both. Vibrators shall not be used to move concrete within the forms. Vibrators shall be used as specified in 901.63C and as directed by the Engineer. Concrete shall be placed and consolidated in a way that minimizes the presence of surface voids or bug holes on the formed surfaces. When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

M. Finishing of Concrete.

The top of the prestressed concrete beams shall be given a float finish except for those areas that will have concrete cast against them, which shall receive a rake finish with a ¼" amplitude applied longitudinally along the length of the beam to the limits shown on the plans.

N. Exposed Surfaces of Prestressed Concrete Beams.

As soon as conditions permit, before the concrete has fully hardened, all dirt, laitance, and loose aggregate shall be removed from the exposed concrete surfaces. Contractor shall not allow foot traffic on the uncured concrete until it has reached sufficient strength to prevent damage.

O. Initial Curing Methods.

After the placement of concrete and prior to concrete finishing, the Fabricator shall initiate initial curing methods when the concrete surface begins to dry, to reduce moisture loss from the surface. Application of one or more of the following initial curing methods shall occur immediately after the bleed water sheen has disappeared.

1. Fogging.

Fogging nozzles shall atomize water into a fog-like mist. The fog spray shall be directed and remain visibly suspended above the concrete surface, to increase the humidity of the air and reduce the rate of evaporation. Water from fogging shall not be worked into the surface during finishing operations and shall be removed or allowed to evaporate prior to finishing.

2. Liquid-applied Evaporation Reducers

Evaporation reducers shall be sprayed onto the freshly placed concrete surface to produce an effective monomolecular film that reduces the risk of plastic-shrinkage cracking and rate of evaporation of the bleed water from the concrete surface. Evaporation reducers shall be applied in accordance with manufacturer's recommendations.

P. Intermediate Curing Methods.

The Fabricator shall initiate intermediate curing methods if concrete finishing has taken place prior to the concrete reaching final set. The freshly finished concrete surface shall be protected from moisture loss, by the continuation of initial curing methods (fogging and evaporation reducers) until final curing methods are applied or by the use of liquid membrane-forming curing compounds (see *Liquid Membrane-Forming Compounds for Curing* section).

Q. Final Curing Methods.

The Fabricator shall initiate and apply final curing methods to the concrete immediately after the following conditions are met:

(a) Completion of concrete finishing
(b) Final set of concrete
(c) Concrete has hardened sufficiently enough to prevent surface damage

During fabrication of Prestressed Concrete Beams, the Fabricator shall maintain the required concrete temperature ranges throughout the entire duration of the final curing method cycle as specified herein. Controlled and gradual termination of the final curing

method shall occur after all specified conditions are met. The concrete temperature shall be reduced at a rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the final curing method enclosure. The Fabricator shall maintain a minimum concrete temperature of 40°F until 100% f'c is attained (see *Handling and Storage* section below).

1. Water Spray Curing.

All exposed concrete surfaces shall remain moist with a continuous fine spray of water throughout the entire duration of the final curing method cycle (see *Table 4: Final Curing Method Cycle for Water Spray*).

Table 4: Final Curing Method Cycle for Water Spray

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Five (5) days	≥ 80% f'_c

2. Saturated Covers for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of saturated covers throughout the entire duration of the final curing method cycle (see *Table 5: Final Curing Method Cycle for Saturated Covers*). Saturated covers shall be allowed to dry thoroughly before removal to provide uniform, slow drying of the concrete surface.

Table 5: Final Curing Method Cycle for Saturated Covers

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Three (3) days	≥ 80% f'_c

Saturated covers, such as burlap, cotton mats, and other coverings of absorbent materials shall meet the requirements of AASHTO M 182, Class 3. Saturated covers shall be in good condition, free from holes, tears, or other defects that would render it unsuitable for curing concrete. Saturated covers shall be dried to prevent mildew when storing. Prior to application, saturated covers shall be thoroughly rinsed in water and free of harmful substances that are deleterious or cause discoloration to the concrete. Saturated covers shall have sufficient thickness and proper positioning onto the concrete surface to maximize moisture retention.

Saturated covers shall contain a sufficient amount of moisture to prevent moisture loss from the surface of the concrete. Saturated covers shall be kept continuously moist so that a film of water remains on the concrete surface throughout the entire duration of the final curing method cycle. The Fabricator shall not permit the saturated covers to dry and absorb water from the concrete. Use of polyethylene film (see *Polyethylene Film* section) may be applied over the saturated cover to potentially decrease the need for continuous watering.

3. Sheet Materials for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of curing sheet materials throughout the entire duration of the final curing method cycle (see *Table 6: Final Curing Method Cycle for Curing Sheet Materials*).

Table 6: Final Curing Method Cycle for Sheet Materials

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Three (3) days	≥ 80% f'_c

Sheet Materials used for curing, such as polyethylene film, white burlap-polyethylene sheeting, and reinforced paper shall meet the requirements of ASTM C171 and the specifications herein. Sheet materials shall inhibit moisture loss and reduce temperature rise in concrete exposed to radiation from the sun during the final curing method cycle. Adjoining covers shall overlap not less than 12 inches. All edges of the covers shall be secured to maintain a moist environment.

(a) Polyethylene Film.

Polyethylene film shall meet the requirements of ASTM C171, consist of a single sheet manufactured from polyethylene resins, be free of visible defects, and have a uniform appearance. Careful considerations shall be taken by the Fabricator to prevent the film from tearing during storage and application, so as to not disrupt the continuity of the film (polyethylene film reinforced with glass or other fibers is more durable and less likely to be torn). The Fabricator shall monitor the application of the film to prevent uneven spots from appearing (mottling) on the concrete surface, due to variations in temperature, moisture content, or both. The Fabricator shall prevent mottling from occurring on the concrete surface by applying additional water under the film or applying a combination of polyethylene film bonded to absorbent fabric to the concrete surface to retain and evenly distribute the moisture.

Immediately following final finishing, polyethylene film shall be placed over the surface of the fresh concrete surface, so as to not damage the surface of the concrete and shall be placed and weighted so that it remains in contact with the concrete throughout the entire duration of the final curing method cycle. The film shall extend beyond the edges of the concrete surface. The film shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling. Edges of adjacent polyethylene film shall overlap a minimum of 6 inches and be tightly sealed with the use of sand, wood planks, pressure-sensitive tape, mastic, or glue to maintain close contact with the concrete surface, retain moisture, and prevent the formation of air pockets throughout the entire duration of the final curing method cycle.

(b) White Burlap-Polyethylene Sheeting

White burlap-polyethylene sheeting shall meet the requirements of ASTM C171, be securely bonded to the burlap so to avoid separation of the materials during handling and curing of the concrete, and be applied in the same manner as the polyethylene film.

(c) Reinforced Impervious Paper.

Reinforced impervious paper shall meet the requirements of ASTM C171, consist of two sheets of kraft paper cemented together with a bituminous adhesive and reinforced with embedded cords or strands of fiber running in both directions, and be white in color. Reinforced impervious paper shall be treated to prevent tearing when wetted and dried.

Reinforced impervious paper can be reused so long as it is effective in retaining moisture on the concrete surface. The Fabricator shall visually inspect the reinforced impervious paper for all holes, tears, and pin holes from deterioration of the paper through repeated use by holding the paper up to the light. The paper shall be discarded and prohibited from use when the moisture is no longer retained.

After the concrete has hardened sufficiently to prevent surface damage, the concrete surface shall be thoroughly wetted prior to the application of the reinforced impervious paper, and be applied in the same manner as the polyethylene film.

4. Liquid Membrane-Forming Compounds for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of liquid membrane-forming compounds throughout the entire duration of the final curing method cycle (see *Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds*).

Table 7: Final Curing Method Cycle for Liquid Membrane-Forming Compounds

Sustained Concrete Temperature	Final Curing Method Cycle Duration	Compressive Strength
50°F ≤ °F ≤ 90°F	≥ Seven (7) days	≥ 80% f'_c

Liquid membrane-forming compounds shall meet the requirements of ASTM C 1315, Type I, Class A and shall exhibit specific properties, such as alkali resistance, acid resistance, adhesion-promoting quality, and resistance to degradation by ultraviolet light, in addition to moisture-retention capabilities. Liquid membrane-forming compounds shall consist of waxes, resins, chlorinated rubber, or other materials to reduce evaporation of moisture from concrete. Liquid membrane-forming compounds shall be applied in accordance with the manufacturer’s recommendations.

Liquid membrane-forming compounds shall be applied immediately after the disappearance of the surface water sheen following final finishing. All exposed surfaces shall be wetted immediately after form removal and kept moist to prevent absorption of the compound, allowing the curing membrane to remain on the concrete surface for proper membrane moisture retention. The concrete shall reach a uniformly damp appearance with no free water on the surface prior to the application of the compound.

If patching or finishing repairs are to be performed prior to the application of the compound, the Precast Concrete Bridge Element shall be covered temporarily with saturated covers until the repairs are completed and the compound is applied. Only areas being repaired shall be uncovered during this period. While the saturated covers are removed to facilitate the patching process, the work shall continue uninterrupted. If for any reason the work is interrupted, saturated covers shall be placed onto the uncovered concrete

surface, until the work continues and is completed, at which time the curing compound shall be applied to the repaired area.

Careful considerations shall be made by the Fabricator to determine if the evaporation rate is exceeding the rate of bleeding, thus causing the surface to appear dry even though bleeding is still occurring. Under such conditions, the application of liquid membrane-forming compounds to the concrete surface shall be delayed, in order to prevent bleed water from being sealed below the concrete surface and avert map cracking of the membrane films, reduction in moisture-retention capability, and reapplication of the compound. To diagnose and prevent this condition, the Fabricator shall place a transparent plastic sheet over a test area of the uncured and unfinished concrete surface and shall determine if any bleed water accumulates under the plastic.

The compound shall be applied in two applications at right angles to each other to ensure uniform and more complete coverage. On very deeply textured surfaces, the surface area to be treated shall be at least twice the surface area of a troweled or floated surface. In such cases, two separate applications may be needed, each at 200 ft^2/gal., with the first being allowed to become tacky before the second is applied.

The curing compound shall be applied by power sprayer, using appropriate wands and nozzles with pressures between 25 and 100 psi. For very small areas such as repairs, the compound shall be applied with a wide, soft-bristled brush or paint roller. The compound shall be stirred or agitated before use and applied uniformly in accordance with the manufacturer’s recommended rate. The Fabricator shall verify the application rates are in accordance with the manufacturer’s recommended rate.

When the concrete surface is to receive paint, finishes, or toppings that require positive bond to the concrete, it is critical that the curing procedures and subsequent coatings, finishes, or toppings be compatible to achieve the necessary bond

After the termination of the final curing method cycle has occured, liquid membrane-forming compounds shall be removed by blast-cleaning from any concrete surface that is to receive paint, finishes, plastic concrete from secondary pour, grout, or any other toppings that require bonding to the concrete surface. These surfaces shall be further blast-cleaned to remove the cement matrix down to exposed aggregate to ensure proper bonding to the material. The method used to remove the curing compound shall not damage the reinforcement and coating. Compounds are prohibited on any concrete surface that will have a penetrating or coating type treatment such as a sealer, stain, or waterproofing membrane applied to it.

5. Accelerated Curing.

Accelerated curing shall use live steam or radiant heat with moisture in accordance with PCI MNL-116 as modified herein. The concrete temperature shall meet the maximum heat increase and cool down rates as specified herein. Concrete temperature monitoring shall meet the requirements of the *Temperature Monitoring* section. Excessive and fluctuating rates of heating and cooling shall be prohibited. The concrete temperature shall not exceed 158°F at any time. The Fabricator shall meet the following accelerated curing sequencing and requirements.

(a) Initial Delay Period.

The initial delay period shall be defined as the duration immediately following the placement of the concrete and the attainment of initial set of the concrete. The Fabricator shall determine the time of initial set in accordance with AASHTO T 197 specifications. Throughout the entire duration of the initial delay period, initial curing shall be implemented. The temperature increase period (see *Temperature Increase Period* section) shall not occur until initial set of the concrete is attained. During the initial delay period, the concrete temperature shall meet the following requirements:

i. Concrete temperature rate of increase shall not exceed 10°F per hour.
ii. Total concrete temperature increase shall not exceed 40°F higher than the placement concrete temperature or 100°F, whichever is less

(b) Temperature Increase Period.

The temperature increase period shall be defined as the duration immediately following the completion of the initial delay period (after initial set) and immediately prior to the start of the constant maximum temperature period. Application of steam to the enclosure shall not occur until the initial delay period is complete. After the initial delay period is complete, all exposed concrete surfaces shall be cured in a moist environment where the concrete temperature increases at a rate not to exceed 36°F per hour.

(c) Constant Maximum Temperature Period.

The constant maximum temperature period shall be defined as the duration immediately following the completion of the temperature increase period and immediately prior to the start of the temperature decrease period. After the temperature increase period is complete, all exposed concrete surfaces shall be cured in a moist environment at a controlled and constant elevated temperature throughout the entire duration of the constant maximum temperature period. Termination of the constant maximum temperature period and the start of the termination decrease period shall occur after all specified conditions are met (see *Table 8: Constant Maximum Temperature Period*).

Table 8: Constant Maximum Temperature Period

Sustained Concrete Temperature	Constant Maximum Temperature Period	Compressive Strength
120°F ≤ °F ≤ 158°F	6 hrs ≤ Time ≤ 48 hrs	≥ 80% f'_c

(d) Temperature Decrease Period.

After the constant maximum temperature period is complete, the concrete temperature shall be cured in a moist environment at a controlled and reduced rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the curing enclosure.

R. Release.

The Fabricator shall not release strands or handle the Prestressed Concrete Beam until Quality Control compressive strength cylinders attain a minimum compressive strength of 80% Design Strength (f'_c) or the specified detensioning compression strength as indicated on the approved shop drawings has been achieved. All exposed concrete surfaces shall continue to be cured in conformance with the *Final Curing Methods* sections until completion.

S. Handling and Storage of Prestressed Concrete Beams.

Prestressed Concrete Beams may be exposed to temperatures below freezing (32°F) when the chosen curing cycle has been completed, provided that the following conditions are met:

(a) Prestressed Concrete Beams are protected from precipitation with polyethylene curing covers until 100% f'_c is attained
(b) Prestressed Concrete Beams maintain a minimum concrete temperature of 40°F until 100% f'_c is attained

Prestressed Concrete Beams damaged during handling and storage will be repaired or replaced at MassDOT's direction at no cost to MassDOT. Prestressed Concrete Beams shall be lifted at the designated points by approved lifting devices embedded in the concrete and in accordance with proper lifting and handling procedures. Storage areas shall be smooth and well compacted to prevent damage due to differential settlement. Prestressed Concrete Beams shall be supported on the ground by means of continuous blocking, in accordance with the approved dunnage plan.

Prestressed Concrete Beams shall be loaded on a trailer with blocking as described above, in accordance with the approved dunnage plan. Shock-absorbing cushioning material shall be used at all bearing points during transportation of the Prestressed Concrete Beams. Blocking shall be provided at all locations of tie-down straps. Prestressed Concrete Beams stored prior to shipment shall be inspected by the Contractor prior to being delivered to the site to identify damage that would be cause for repair or rejection.

T. Repairs and Replacement.

In the event defects are identified, they shall be classified in the following categories and a non-conformance report (NCR) shall be filed if required. The NCR shall be submitted to MassDOT for review. Defects in all categories shall be documented by plant Quality Control personnel and made available to MassDOT upon request. Any required repairs shall utilize materials listed on the MassDOT QCML.

Where noted, defects shall be repaired according to the PCI Northeast Region Guidelines for Resolution of Non-Conformances in Prestressed Concrete Beams, Report Number PCINE-18-RNPCBE. Please note that reference to PCINE-18-RNPCBE is made for repair details only. In the case of conflicts with this Special Provision, this Special Provision shall govern.

1. Category 1, Surface Defects.

Category 1 defects do not need to be repaired, and an NCR does not need to be filed. Surface defects are defined as the following:

(a) Surface voids or bug holes that are less than 5/8-inch in diameter and less than ¼-inch deep, except when classified as Category 4
(b) Cracks less than or equal to 0.006 inches wide
(c) Cracks less than or equal to 0.125 inches wide on surfaces that will receive a concrete overlay or spray-applied membrane waterproofing

2. Category 2, Minor Defects.
Category 2 defects shall be repaired, but an NCR does not need to be filed. Minor defects are defined as the following:

(a) Spalls, honeycombing, surface voids that are less than 2 inches deep and have no dimension greater than 12 inches
(b) Cracks less than or equal to 0.016 inches that will not receive a concrete overlay or spray-applied membrane waterproofing
(c) Broken or spalled corners that will be covered by field-cast concrete

Minor defects shall be repaired according to PCINE-18-RNPCBE. Cracks shall be sealed according to the PCI Repair Procedure #14 in PCINE-18-RNPCBE.

3. Category 3, Major Defects.
For Category 3 defects, the Fabricator shall prepare an NCR that documents the defect and describes the proposed repair procedure. The NCR shall be submitted to MassDOT for approval prior to performing the repair. Major defects are defined as the following:

(a) Spalls, honeycombing and surface voids that are deeper than 2 inches or have any dimension greater than 12 inches, when measured along a straight line
(b) Concentrated area of defects consisting of four or more Category 2 Defects within a 4-square foot area
(c) Exposed reinforcing steel
(d) Cracks greater than 0.016 inches and less than or equal to 0.060 inches in width that will not receive a concrete overlay or spray-applied membrane waterproofing
(e) Bearing area spalls with dimensions not exceeding 3 inches
(f) Cracks, spalls and honeycombing that will be encased in cast in place concrete need not be repaired, but the limits and location of the defects shall be documented with an NCR

Upon MassDOT approval, defects and cracks shall be repaired according to PCINE-18-RNPCBE and this specification. All repairs shall be completed at the expense of the Contractor.

4. Category 4, Rejectable Defects.

Rejectable defects as determined by the MassDOT Inspector, RMS, and Engineer may be cause for rejection. Fabricator may submit an NCR with a proposed repair procedure, requesting approval. Some rejectable defects are defined as the following:

(a) Surface defects on more than 5% of the surface area which will be exposed to view after installation
(b) Minor defects that in total make up more than 5% of the surface area of the unit
(c) Cracks greater than 0.060 inches in width except as noted in Category 1
(d) Elements fabricated outside of the specified tolerances
(e) MassDOT compressive strength testing that does not meet the specified Design Strength, f'_c

U. Loading.

Prior to the Fabricator loading the Precast Bridge Element on to the truck for shipping, the Fabricator shall provide the MassDOT Plant Inspector and RMS a minimum seven (7) days' notice of the Fabricator's intent to load the Precast Bridge Element. Inspection by the MassDOT Plant Inspector shall take place while the element is still on dunnage in the yard. The element shall not be loaded onto the truck until the MassDOT Plant Inspector has performed the inspection.

V. Shipping.

Prior to shipment, the Fabricator shall perform the following actions and provide the required documentation to the MassDOT Plant Inspector:

(a) Prestressed Concrete Beams shall remain at the Fabricator's plant for a minimum of 7 days after cast date.
(b) QC Inspection Reports shall be signed by the Quality Control Manager and provided to the MassDOT Plant Inspector.
(c) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Prestressed Concrete Beam's representative sublot shall be generated by the Fabricator and provided to the MassDOT Plant Inspector.
(d) Certificate of Compliance shall be generated by the Fabricator as described under the Fabricator Quality Control section and provided to the MassDOT Plant Inspector.
(e) All MassDOT RMS approved Corrective Actions submitted on the Non-Conformance Reports (NCR), shall be verified to have been completed by the MassDOT Plant Inspector and Quality Control Manager.
(f) All NCRs shall be signed off by the Quality Control Manager, MassDOT Inspector and MassDOT RMS.

W. Delivery.

Upon Delivery, the following documentation shall be provided to the MassDOT Resident Engineer or designee:

(d) QC Compressive Strength Test Report Forms attaining Design Strength, f'c for the Prestressed Concrete Beam's representative sublot.
(e) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(f) QC Inspection Reports signed by the Quality Control Manager.

The Contractor shall inspect the Prestressed Concrete Beams upon receipt at the site. Prestressed Concrete Beams damaged during delivery shall be repaired or replaced at MassDOT's direction at no cost to MassDOT.

CONSTRUCTION METHODS – FIELD CONSTRUCTION

I. General.

All of the Contractor's field personnel involved in the erection and assembly of the Prestressed Concrete Beams shall have knowledge of and follow the approved Erection Procedure and Quality Control Plan for Prestressed Concrete Beam Assembly.

Prior to installation, the following documentation shall be reviewed and confirmed by the MassDOT Resident Engineer or designee:

(a) QC Compressive Strength Test Report Forms attaining Design Strength, f'_c for the Prestressed Concrete Beam's representative sublot.
(b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
(c) QC Inspection Reports signed by the Quality Control Manager.

Field construction staff shall verify that the Resident Engineer has accepted all Prestressed Concrete Beams prior to installation.

A. Erection Procedure and Quality Control Plan for Prestressed Concrete Beam Assembly.

Prior to the erection, the Contractor shall submit an Erection Procedure and a Quality Control Plan for Prestressed Concrete Beam Assembly for approval by the Engineer. This submittal shall include computations and drawings for the transport, hoisting, erection and handling of the Prestressed Concrete Beams. The Erection Procedure and Quality Control Plan for Prestressed Concrete Beam Assembly shall be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts with working knowledge of the Contractor's equipment, approved shop drawings, and materials to build the bridge. The Erection Procedure and Quality Control Plan for Prestressed Concrete Beam Assembly shall, at a minimum, include the following:

1. Erection Procedure

The Erection Procedure shall be prepared to conform to the requirements of 960.61, Erection and the applicable sections in Chapter 8 of the PCI Design Handbook (seventh edition) for handling, erection, and bracing requirements. At a minimum, the Erection Procedure shall provide:

(a) Steel reinforcing details, and location and details of lifting devices
(b) Minimum concrete compressive strength for handling the Prestressed Concrete Beams.
(c) Concrete stresses stresses during handling, transport, and erection.
(d) Crane capacities, pick radii, sling geometry, and lifting hardware.
(e) Verification that the equipment can handle all pick loads and weights with the required factor of safety.
(f) Evaluation of construction sequence and evaluation of any geometric conflicts in the lifting of the Prestressed Concrete Beams and setting them on the abutments and piers.
(g) Design of crane supports including verification of subgrade for support.
(h) Location and design of all temporary bracing that will be required during erection.

2. Quality Control Plan for Prestressed Concrete Beam Assembly

The Quality Control Plan for Prestressed Concrete Beam Assembly is a document prepared and submitted by the Contractor prior to the start of work which requires the Contractor to identify and detail the sequence of construction in accordance with the project schedule and which clearly identifies all stages of field construction. The assembly procedures for the Prestressed Concrete Beams shall be submitted on full size 24”x36” sheets. This document will be treated as a Construction Procedure and will be reviewed by both the Designer and the District Construction Office.

At a minimum, the Quality Control Plan for Prestressed Concrete Beam Assembly shall include the following:

(a) Listing of the equipment, materials, and personnel including their assigned responsibilities that will be used to erect and assemble the Prestressed Concrete Beams on site.
(b) Documentation of all preparatory work necessary for moving personnel, equipment, supplies, and incidentals to the project site before beginning work.
(c) Detailed schedule showing the sequence of operations that the Contractor will follow to complete the field construction from setting working points and working lines to the casting of closure pours and the curing of the closure pour concrete, as described below and as called for on the plans.
(d) For NEDBT and NEXT D beams, Contractor’s means for ensuring that the Prestressed Concrete Beam shall align to the roadway profile and cross slope and means for adjusting the final deck slab elevation.
(e) Timeline and descriptions of Quality Control activities to be followed throughout the field construction operations including methods and procedures for controlling tolerance limits both horizontally and vertically.

B. Survey and Layout.

Working points, working lines, and benchmark elevations shall be established prior to placement of all elements. The Contractor is responsible for field survey as necessary to

complete the work. MassDOT reserves the right to perform additional independent survey. If discrepancies are found, the Contractor may be required to verify previous survey data.

C. Adjacent Prestressed Deck Slabs.

1. Beam Layout and Erection.

Prestressed concrete beams shall be installed to the line and grade shown on the plans in accordance with the Contractor's approved Erection Procedure and Assembly Plan. The location of the beams on the abutments and piers shall be laid out according to the nominal width of the beams as shown on the plans. Each beam shall be erected such that after erection, the beam shall lie entirely within the horizontal lines defined by its nominal width for its entire length and shall not infringe on the space allocated for any adjacent beam.

Immediately prior to erecting the beams, the keyway surfaces shall be cleaned at the job site of all dust, dirt, and carbonation using a high-pressure water blast.

After all beams are erected, the actual overall width of the beams as laid out shall not deviate from the nominal dimension shown on the framing plan beyond a tolerance of +0 inches and -1 inches.

After the beam layout has been accepted by the Engineer, the Contractor shall cut the lifting devices off below the top of the beam.

2. Walkway.

The Contractor may install walkway brackets, posts, and steel grating on the precast beams prior to erection of the beams. Any damage to the walkway components caused during erection shall be repaired by the contractor at no expense to MassDOT.

3. Field Welding of Lateral Restraint Brackets (BK), Longitudinal restraint brackets (LRB).

Restraint brackets shall be field welded to embedded plates only after the beam layout has been accepted by the Engineer.

4. Mastic Field Coating.

Mastic Field coating shall be applied only after bracket installation has been accepted by the engineer.

5. Deck Plates (DP) and Ballast Mat.

Deck Plates and Ballast Mat shall be installed only after the beam layout has been accepted by the engineer.

GEOTECHNICAL INSTRUMENTATION

Work should be performed in accordance with requirements under Items 190.01 and 190.02 in this special provisions.

WILDLIFE PASSAGE AT BR. 79.81

The work of this section is to install stream streambed/bank material in and over the existing streambed, to provide an upland bank along the face of the new south abutment of Br. 79.81 for wildlife passage, to enhance the Willow Creek habitat at the bridge.

The work to be done under this section shall conform to the relevant provisions of Section 983 of the Standard Specifications and the following:

Material

The streambed/bank construction material is to be placed in the existing streambed which will be cut below existing streambed by 1'-0", and in front of the proposed south abutment, as depicted on the plans. The intent of this work is to ensure a natural streambed/bank to be left in place, and in front of the proposed abutment, to provide wildlife habitat enhancement as part of the reconstruction of bridge.

The streambed/bank material shall be comprised of two primary components.

1. Stone 4 inches and under shall meet the following gradation:

Sieve opening	Percent by Mass Passing Through
4"	95
2"	55 – 65
¾"	30 – 45
#4	0 – 5

2. Stone 6 inches to 2.5 foot in diameter:

Stone Size	Percent Passing
2.0'	80
1.5'	25
0.5'	0

The streambed/bank stone for all two components shall be native cobbles and boulders similar in shape and size of streambed/bank stone adjacent to the work area. Partially angular rock is preferred over round and shall be able to lock together to prevent movement during high flows. Crushed Stone will not be accepted for any of the four components. Any stone excavated from the existing streambed can be stockpiled and reused for streambed restoration, provided the excavated stone is characteristic of the existing stream material upstream and downstream of the work area, or meets the above criteria. The elevations and conditions of the existing streambed shall be maintained to the maximum extent practicable.

Construction

Components one and two shall be pre-blended outside the project area at a volume ratio of 30% and 70% respectively. The pre-blending shall be done in a way that will prevent the mass from being contaminated by work-place soils. The pre-blended mass shall be placed over areas to be cut below streambed as shown on the plans.

TEMPORARY SHORING/ SUPPORTS

The Contractor is responsible for maintaining the stability of bridge structures during construction and provide temporary shoring as needed in addition to the temporary shoring required on the plans.

Temporary shoring for the two existing center piers and stone retaining walls of Bridge 77.04 are required during pile installation. Calculations and drawings of temporary shoring shall be prepared and stamped by a professional structural engineer registered in the Commonwealth of Massachusetts and submitted to the engineer for review and approval before installation of piles and steel sheet piles.

Designs for temporary shoring shall be accordance with the latest edition of American Railway Engineering and Maintenance -of-way Association (AREMA) "Manual for Railway Engineering.

Cost of temporary shoring/supports shall be incidental to Items 995.01 & 995.02.

TEMPORARY TIMBER MAT ON BRIDGES FOR CONSTRUCTION PHASING

The contractor is responsible for means and methods of construction including sequencing of construction. After the new bridge structure is installed and before the track profile is raised to the final location, the track may need to be temporarily supported by the new bridge without ballast under track. If a timber mat will be used under the track for spreading train load on the new bridge for the temporary condition, the mat shall be made of butted crossties and shall be minimum 7" deep and 8'-6" wide. The details of timber mat and connections to track shall be submitted for the Engineer's review. The Contractor may propose alternate method for consideration by the Engineer

SCHEDULE OF BASIS FOR PARTIAL PAYMENT

Within 10 days after the date of the Notice to Proceed, the Contractor shall submit, in duplicate, for the approval of the Engineer, a schedule of unit prices for the major component Sub-Items that make up the bridge work as well as his/her total bridge structure Lump Sum cost for the bridge work. The total of all partial payments to the Contractor shall equal the Lump Sum contract price regardless of the accuracy of the quantities furnished by the Engineer for the individual bridge components. The cost of labor and materials for any item not listed but required to complete the work shall be considered incidental to Items 995.01 and Items 995.02 and no further compensation will be allowed.

Item 995.01, BRIDGE STRUCTURE, BRIDGE NO 77.04

Sub-Item Description	Quantity	Unit	Unit Price	Total
Bridge Excavation	433	CY		
Steel Grating For Walkway	93	SF		
Bridge Handrail	64	LF		
Elastomeric Bridge Bearing Pad	36	SF		
Structural Steel – Coated Steel	2125	LB		
Precast Abutment Cap	2	EA		
Precast Pier Cap	1	EA		
Prestressed Concrete Slab	83	FT		
Precast Concrete Wingwall Panel	2	EA		
Concrete Pile Protection for Pier Pile.	1	LS		
Geotechnical Instrumentation for Bridge 77.04	1	LS		
Temporary Shoring	1	LS		
Total Cost of Item 995.01 =				

Item 995.02, BRIDGE STRUCTURE, BRIDGE NO 79.81

Sub-Item Description	Quantity	Unit	Unit Price	Total
Bridge Excavation	177	CY		
Steel Grating Walkway	83	SF		
Bridge Handrail	38	LF		
Elastomeric Bridge Bearing Pad	32	SF		
Structural Steel – Coated Steel	575	LB		
Precast Abutment Cap	2	EA		
Precast Pier Cap	1	EA		
Precast Concrete Approach Slab	4	EA		
Prestressed Concrete Slab	74	FT		
Geotechnical Instrumentation for Bridge 79.81	1	LS		
Wildlife Passage	1	LS		
Cast-in-Place Concrete Enclosures at Abutments	1	LS		
Temporary Shoring	1	LS		
Total Cost of Item 995.02 =				

END OF SECTION

DOCUMENT A00820

Massachusetts Department of Transportation
Conditions of Custody

REQUEST FOR RELEASE OF MASSDOT AUTOCAD FILES FORM
(Only to be used following award of contract)

City/Town: LENOX AND LEE

Project File Number: 613045

Contract Number: 120593

Project Description: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line

All AutoCAD files are provided solely as a courtesy to facilitate public access to information. MassDOT attempts to provide current and accurate information but cannot guarantee so. MassDOT provides such documents, files or other data "as is" without any warranty of any kind, either expressed or implied, including but not limited to, accuracy, reliability, omissions, completeness and currentness. The Commonwealth of Massachusetts and its Consultants shall not be liable for any claim for damages, including lost profits or other consequential, exemplary, incidental, indirect or special damages, relating in any way to the documents, files or other data accessible from this file, including, but not limited to, claims arising out of or related to electronic access or transmission of data or viruses. Because data stored on electronic media can deteriorate undetected or be modified without our knowledge, MassDOT cannot be held liable for its completeness or correctness. MassDOT makes no representation as to the compatibility of these files beyond the version of the stated CAD software.

By signing this form, I agree that it shall be my responsibility to reconcile this electronic data with the conformed contract documents, and that only the conformed contract documents shall be regarded as legal documents for this Project. I understand that this authorization does not give me the right to distribute the files. I agree to the terms above and wish to receive the AutoCAD files.

This signed form shall be mailed to:

Scott Conti
MassDOT – Rail and Transit Division
10 Park Plaza, Room 4160
Boston, MA 02110

Name of person requesting AutoCAD files: ____________________

Affiliation/Company: ____________________

Address: ____________________

____

Telephone number: ____________________

Email address: ____________________

Signature/Date: ____________________

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DOCUMENT A00841

MASSACHUSETTS
Department of Environmental Protection

Water Quality Certificate

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Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

Western Regional Office • 436 Dwight Street, Springfield MA 01103 • 413-784-1100

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

ISSUED ELECTRONICALLY ONLY

Scott Conti
Rail and Transit Division
Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, Massachusetts 02116
scott.conti@dot.state.ma.us

August 27, 2021

Re: WATER QUALITY CERTIFICATION
Application for: BRP WW 11
MINOR FILL AND EXCAVATION PROJECT
Housatonic Railroad Bridges Replacement Project
Codding Brook and Willow Creek
Berkshire Line
Bridge 77.04 over Codding Brook in Lee and Bridge 79.81 over Willow Creek in Lenox
Lee and Lenox, Massachusetts

USACOE Application Number:	not yet issued
MassDEP Wetlands File Number:	n/a (Exempt)
MassNHESP File Number:	20-39785
Massachusetts Historical Commission:	RC.69409 and RC.69424
Transmittal Number:	**X287167**

Dear Mr. Conti:

The Massachusetts Department of Environmental Protection (hereinafter the Department) has completed its Supplemental Technical Review of the permit application for the project listed above. In accordance with the provisions of Massachusetts General Laws, Chapter 21, Sections 26 through and including 53 and the Regulations promulgated thereunder at 314 CMR 9.00, and its subpart at 314 CMR 9.09(1)(c); and Section 401 of the federal Clean Water Act as amended (33 USC §1251 et seq.), it has been determined that there is reasonable assurance this “railroad bridges replacement project” will be conducted in a manner which will not violate applicable Surface Water Quality Standards at 314 CMR 4.00 *Massachusetts Surface Water Quality Standards* as implemented and supplemented, without limitation at 314 CMR 9.00; and other applicable requirements of state law.

Findings:

- The Activity (as defined at 314 CMR 9.02) described within the Water Quality Certification application and supplemental information (hereinafter the "application") will result in the Discharge of Dredged or Fill Material (hereinafter "Discharge") into and within Waters of the United States within the Commonwealth (hereinafter "WUSWC") [each as defined at 314 CMR 9.02] at the Project Locus described below;
- The application involves a Lot (as defined at 314 CMR 9.02) referred to as the Berkshire Line, and specifically an existing railroad bridge at Milepost 77.04 over Codding Brook located within the Town of Lee, Berkshire County, Massachusetts; and an existing railroad bridge at Milepost 79.81 over Willow Creek in the Town of Lenox, Berkshire County, Massachusetts (hereinafter the "Project Locus");
- The Project Locus contains and includes WUSWC which have been determined to meet the jurisdictional definition of Bordering Vegetated Wetland (BVW) (as defined at 314 CMR 9.02); and Land Under Water (LUW);
- The Department hereby approves the following site plan(s) and documents as the "plan(s) of record":
  - "Massachusetts Department of Transportation-Rail and Transit Division, Replacement of Berkshire Line Bridge No. 77.04, Project Location: Lee, MA, Permit Plans", Sheets 1 through 4 of 4, dated February 12, 2021, prepared by HDR, Inc.;
  - "Massachusetts Department of Transportation-Rail and Transit Division, Replacement of Berkshire Line Bridge No. 79.81, Project Location: Lenox, MA, Permit Plans", Sheets 1 through 4 of 4, dated February 12, 2021, prepared by HDR, Inc.;
  - "Wetland Replication Report" prepared by Epsilon Associates, Inc., undated;
  - "Western Regional Office, Bureau of Water Resources, Wetlands Program Restoration Plan in Response to Information Request Letter, Data Required for Proposed Bordering Vegetated Wetland Restoration/Replication Area(s) Per Massachusetts Inland Wetland Replication Guidelines (MassDEP 2002) and 310 CMR 10.55(2)(b)1. through 7. and 314 CMR 9.06(2)"
- The boundary of the Bordering Vegetated Wetland(s) on the parcel in question are demarcated as shown on the plan(s) of record;
- The boundary of Land Under Water on the parcel in question is demarcated at the High Water Mark [as defined at 314 CMR 9.02] as shown on the plan(s) of record;
- The Bordering and/or Isolated Vegetated Wetlands and/or Land Under Water (collectively WUSWC) bounded as described above constitute the "Project Site";
- The Department has determined that the project, as shown on the plan(s) of record and further described in supplemental information, is the "least environmentally damaging practicable alternative", and therefore meets the criteria at 314 CMR 9.06(1);
- The project, as approved in this Water Quality Certification, will result in the permanent Discharge into 246 square feet of Bordering Vegetated Wetland and 8 square feet of Land Under Water associated with Codding Brook [Stream and River Inventory System (SARIS) Number 2104925]; and Willow Creek (SARIS Number 2105050);
- The sum of these proposed activities will result in the Discharge into **254** square feet of WUSWC;

- Per the authority of the Department at 314 CMR 9.09(1)(d), the Department has determined that the 1,100 square foot *ex situ* Bordering Vegetated Wetland "Compensatory Mitigation Area(s)" located in and adjacent to Hop Brook (SARIS Number 2104625) in the Hop Brook Wildlife Management Area in the Town of Lenox, Massachusetts, as described within the plan(s) of record and supporting documentation, meet the criteria at 314 CMR 9.06(2)(a); and adequately minimizes damage to the Aquatic Ecosystem [as defined at 314 CMR 9.02] therein associated, and as conditioned by this Water Quality Certification;
- Per the authority of the Department at 314 CMR 9.09(1)(d), the Department has determined that the proposed project maintains water quality within Land Under Water on the Site, and adequately minimizes damage to the Aquatic Ecosystem [as defined at 314 CMR 9.02] therein associated, through application of the mitigation proposed, and as conditioned by this Water Quality Certification;
- Codding Brook (SARIS Number 2104925) and Willow Creek (SARIS Number 2105050) are listed as Coldwater Fish Resources (CFR) by the Fisheries Program of the Massachusetts Division of Fisheries and Wildlife, and thus meet the definition at Cold-water Fisheries (314 CMR 9.02).
- The Department has determined that proposed Activities will occur, at least in part, within WUSWC that is also designated Rare Species Habitat (as defined at 314 CMR 9.02), and after consultation with the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife, has approved and conditioned such Activities in accordance with 314 CMR 9.06(2).
- The Department has determined that the proposed replacement crossing of Codding Brook, a non-tidal river shown on the plan(s) of record, complies with 314 CMR 9.06(2)(b)1. and 4., as it meets the applicable provisions of the Massachusetts River and Stream Crossing Standards (as defined at 314 CMR 9.02).
- Per the definition of Water-dependent at 314 CMR 9.02, which invokes 310 CMR 9.12(2)(f)8., land-based railway transportation infrastructure is classified as non-water dependent *unless* it meets the standard at 310 CMR 9.12(2)(d), in that it is an Infrastructure Crossing Facility for an Infrastructure Facility (each as defined at 310 CMR 9.02). As publicly-owned transportation facilities meet this definition, MassDEP hereby issues a finding that the proposed project is Water-Dependent (as defined at 314 CMR 9.02). Thus, the scope of an alternatives analysis is found at 314 CMR 9.06(1) and its subpart (a), which then allows 314 CMR 9.06(2)(b)4. to serve as the sole parameter of the requisite alternatives analysis for Codding Brook.
- The Department has determined that the proposed replacement crossing of Willow Creek is not subject to the standards at 314 CMR 9.06(2)(b)4. Instead, the standards at 314 CMR 9.06(1) and 314 CMR 9.06(2)(a) apply, and MassDEP has determined that the proposed work will not have an adverse effect upon the Aquatic Ecosystem (as defined at 314 CMR 9.02) associated with Willow Creek.

Water Quality Certification Conditions for Transmittal Number X287167

Therefore, based on information currently in the record, the Department **grants a Water Quality Certification** (hereinafter "Certification") for this project subject to the following conditions

necessary to maintain water quality, to minimize impact to WUSWC, and to ensure compliance with appropriate state law:

Administrative and Procedural Conditions

1. This Certification does not relieve the permittee or any other person or party of the necessity of complying with all other applicable federal, state, or municipal statutes, ordinances, bylaws, or regulations, including those administered by the US Army Corps of Engineers. Activities, as defined at 314 CMR 9.02 Activity, conducted in accord with this Certification may only begin following the twenty-one (21) calendar day appeal period, as specified at 314 CMR 9.09(1)(e) and 314 CMR 9.10(2), and once all other required permits and licenses have been received. The permittee shall comply with all the Conditions of the "Department of the Army General Permits, Commonwealth of Massachusetts" (US Army Corps of Engineers, effective on April 16, 2018) (available from the US Army Corps of Engineers, New England District, Regulatory Division at www.nae.usace.army.mil). The General Permits Conditions therein hereby form a part of, and are inseparable from, this Certification.
2. This Certification does not grant any property rights or any exclusive privileges; it does not authorize any injury to private property or invasion of property rights.
3. The permittee, property owner, all successors and assigns in interest or control of the property subject to this Certification and any contractor or other person performing work conditioned by this Certification shall adhere to **all** applicable procedural and technical Conditions of this Certification. All work upon or within WUSWC allowed per this Certification shall be accomplished by reference to the plan(s) of record, and to the several Conditions of this Certification. In the event of any conflict between the several Conditions of this Certification and the plans of record, the Conditions of this Certification shall prevail.
4. The permittee shall arrange to procure and submit a good resolution electronic copy of the plans of record (as referenced above, and as modified and by adding the correct paper size for printing to retain scale) by close-of-business on Friday, October 1, 2021. Upon review and acceptance of these plans of record by the Department, the permittee will affix a prominent "Approved by MassDEP on Month, Date 2021" label upon each sheet, and shall electronically resubmit the plans to the Department. A copy shall be retained by the Department as a permanent record, and a copy shall be retained by the permittee and the general contractor (or equivalent) and made available on appropriately sized paper when requested. Thereafter, all work conducted per this Certification shall fully and completely comply with these plans of record.
5. Prior to the initiation of activities permitted by this Certification, the permittee shall arrange for a videoconference to be held with the Department's Western Region Wetlands Program. It shall be the responsibility of the permittee to propose a platform for this videoconference, with whatever security protocols they may require; and to ensure that their representative(s) (if any), as well as the general contractor, all appointed compliance monitors and environmental consultants required within this Certification (if any), and all other pertinent firms or persons, are in attendance. The permittee shall also ensure that all plans of record, contracts, and other pertinent documents are made available and viewable at this videoconference. No activities otherwise permitted by this Certification may proceed until this videoconference has been held.

6. Should contractors not be able to build according to the plan(s) of record (or any sheet, detail, schematic, or collar note therein) approved in this Certification, because said plans do not accurately reflect site conditions (or standard construction methodologies, or practical construction considerations), the Department maintains the right to require an immediate cessation of work, in whole or in part. Should the Department, at its sole discretion, require such cessation, it shall do so in writing to the permittee, and such notice shall require adequate interim erosion and sedimentation controls and the submittal of proposed plan revisions that address the inadequacies, and result in the same or reduced Discharges to WUSWC as approved in the plan(s) of record. Activities shall not recommence until written approval to proceed has been issued by the Department.
7. Codding Brook and Willow Creek and their associated tributaries and Bordering Vegetated Wetlands are classified in the Massachusetts Surface Water Quality Standards (314 CMR 4.00) as Class B, High Quality Waters. As such, they are protected by the antidegradation provisions specified in 314 CMR 4.04(1) and the last clause of 314 CMR 4.04(2). The antidegradation provisions are implemented and supplemented, without limitation, by 314 CMR 9.00, per 314 CMR 9.01(3). Therefore, reasonable care and diligence shall be taken by the permittee to assure that the proposed activity will be conducted in a manner that will avoid violations of these Standards.
8. The contractor(s) employed to execute earth-moving, vegetation removal, demolition, and/or motorized vehicle operation activities on the property subject to this Certification must be provided a copy of this Certification prior to the commencement of any such activities. Said contractor(s) may be held responsible with the permittee and property owner for violations by the contractor, and may be subject to penalties authorized by law and/or regulation for those violations.
9. This Certification specifically prohibits any Activity (as defined at 314 CMR 9.02) within or upon any WUSWC not specifically authorized by this Certification. Any failure to abide by the Conditions of this Certification that results in or contributes to a Discharge into WUSWC shall result in an enforcement action by and at the discretion of the Department, and possibly other regulatory agencies.
10. As this project has been determined to meet the definition of Single and Complete Project at 314 CMR 9.02, the amount of proposed Discharge within WUSWC permitted by this Certification shall not be exceeded, regardless of future project modifications or any proposed modifications under Condition #11 of this Certification. This prohibition does not expire.
11. The Department shall be notified in writing of any proposed changes in construction methodology or design necessary to complete this project. Any proposed modifications involving additional Discharge are strictly prohibited. Proposed reduction of Discharge may be submitted under this Condition. Based upon submittals under this Condition, the Department will determine whether any proposed changes will require an “Amendment” to this Certification per the Department’s authority at 314 CMR 9.09(2).
12. Failure to comply with this Certification is grounds for enforcement, including but not limited to civil and criminal penalties, under MGL c. 21, § 42; 314 CMR 9.00; MGL c. 21A, § 16; 310 CMR 5.00; or other possible actions/penalties as authorized by the General Laws of the Commonwealth of Massachusetts.

13. Department staff shall have the right to enter and inspect the property subject to this Certification at reasonable hours to evaluate compliance with the Conditions of this Certification.
14. This Water Quality Certification expires on April 5, 2023, unless the US Army Corps of Engineers, New England District, Regulatory Division specifically authorizes a different expiration date in writing in a Pre-Construction Notification <u>Authorization</u> or <u>Individual Permit</u> issued under § 404 of the federal Clean Water Act and the "Department of the Army General Permits, Commonwealth of Massachusetts" (US Army Corps of Engineers, effective April 16, 2018) issued thereunder.

<u>Site Stabilization Conditions</u>

15. This Certification prohibits the discharge of any amount of untreated sediment-laden stormwater at any time from within or adjacent to the Project Site to any WUSWC outside the demarcated limit-of-work, as shown on the plan(s) of record. This prohibition applies regardless of any structural or nonstructural stormwater best management practices otherwise required by this Certification or any other regulatory authority; and despite any singular precipitation event, climactic pattern, or related phenomena. Discharges of untreated sediment-laden stormwater in violation of this Condition would constitute a violation of this Certification, and could result in enforcement actions taken by the Department, and possibly other regulatory agencies.
16. Prior to commencement of any work on the Site, adequate erosion and sedimentation control measures shall be implemented, <u>including any necessary controls not specifically referenced in the plan(s) of record</u>, and they shall be maintained in effect throughout the entire project, and until the Site has become stabilized with an adequate vegetative or landscaping cover. Structural failure of the erosion and sedimentation controls required by this Certification, and subsequent discharge of untreated stormwater to WUSWC, would constitute a violation of this Certification, and could result in enforcement actions taken by the Department, and possibly other regulatory agencies.
17. Prior to the commencement of any earth-moving activity a double-staked hay bale barrier (end to end) shall be placed along the limit of activity between all disturbed areas and WUSWC not subject to Discharge, regardless of what is shown on the plan(s) of record. Each bale shall be properly bound with at least two (2) lengths of twine or wire, and shall be entrenched to an excavated depth of at least four (4) inches, but no greater than six (6) inches. Excavated spoils from entrenching shall be deposited on the up-gradient side of the barrier. Bales shall be tightly butted against each other. A geotextile siltation fence shall be placed on the down-gradient side of the aforementioned hay bale barrier, and shall be entrenched in a like manner such that the base of the fabric lies below grade extending at least six (6) inches away from the fence. This fence shall be located no further than twelve (12) inches from the down-gradient side of the hay bale barrier. These erosion and sedimentation controls shall be constructed and installed per this Condition, and shall be maintained in proper functioning condition until all disturbed areas have been stabilized, or until the Department has determined that the control measures are no longer necessary.

Compliance Monitoring Conditions

18. Within ten (10) business days of the issuance date of this Certification, the permittee shall nominate one or more compliance monitors in writing, who shall be accepted in writing by the Department. Nominated compliance monitors shall have adequate and relevant education, training, and/or experience necessary to understand and perform the duties described herein, and the Department reserves the right to accept nominees based upon its review of such education, training, and/or experience, as documented in resumes submitted to the Department. The approved compliance monitor(s) shall personally observe all "construction activity" at all times within all WUSWC permitted by this Certification and subject to it (said compliance monitor can be the same person identified at Condition #20 of this Certification). For purposes of this Certification, "construction activities" are all activities (as defined at 314 CMR 9.02 Activity) within WUSWC which entail the initial placement and/or extraction of fill or materials including:

    a. mechanized vegetation removal and grubbing/land clearing;
    b. the placement and the extraction of the proposed cofferdams;
    c. the initial placement of any material into standing water within WUSWC;
    d. the initial placement of fill and excavation of soil into Bordering and Isolated Vegetated Wetlands;
    e. The removal and placement of any material or substance from or into WUSWC for purposes of mitigation which is required in this Certification

    The compliance monitor(s) are not required to be present for any work:

    f. taking place within areas of Codding Brook or Willow Creek that have been dewatered through drawdown;
    g. taking place in WUSWC after initial placement of fill or materials;
    h. taking place within the area dewatered by the proposed temporary cofferdam;
    i. taking place in areas that are not WUSWC

    In addition to the above, the compliance monitor(s) shall conduct a thorough inspection of the site within 24 hours of any rainfall which equals or exceeds 0.5 inches within 24 hours (as measured from the nearest applicable station on the NOAA "Daily Summaries Map", see https://gis.ncdc.noaa.gov/maps/clim/summaries/daily) or at least once every calendar week during active construction in the absence of a threshold rainfall event as outlined above.

    While performing these duties the compliance monitor(s) shall confirm that all relevant Conditions of this Certification are being complied with at all times whilst they are present.

    While on site, the compliance monitor(s) shall sufficiently document any and all observed noncompliance with any of the Conditions of this Certification. The compliance monitor(s) shall submit such electronic documentation to: David.Cameron@mass.gov. This electronic documentation shall be in the form of a concise written report which adequately describes the noncompliant activities and/or conditions and cites the Condition(s) which have been violated, and shall always be accompanied by the submittal of digital photographs, which

shall clearly and adequately show the nature and extent of noncompliant activities and/or conditions and support the written report. This electronic documentation shall be submitted as such noncompliance is occurring and/or is first noted by the compliance monitor(s). If, in unusual circumstances, this is not physically possible, then the compliance monitor(s) shall submit electronic documentation within no more than four (4) hours of the initial observance of the noncompliant activity and/or condition. Within this same time period, the compliance monitor(s) shall also report the noncompliant activities and/or conditions via telephone to each of the following Department staff: David Cameron at 857-207-1921. Failure to comply with this Condition would constitute a violation of this Certification and could result in enforcement actions taken by the Department. Failure of any compliance monitor to fulfill these duties in compliance with this Condition is grounds for a potential enforcement action against the permittee. The permittee, its employees, agents, successors, and assigns shall not impede the compliance monitor(s) in the performance of their duties under this Certification. Any change in staffing of the compliance monitor(s) must be approved by the Department per Condition #11 of this Certification.

Provision of Bordering and Isolated Vegetated Wetland Compensatory Mitigation Area(s)

19. At least ten (10) business days prior to the initiation of construction, the permittee shall nominate a wetland scientist(s) in writing, who shall be accepted in writing by the Department. Nominated wetland scientist(s) shall have at least five (5) years of experience in developing "Compensatory Mitigation Area" plans for Bordering Vegetated Wetland ("BVW") alteration per 314 CMR 9.06(2) and 310 CMR 10.55(4)(b)1. through 7., inclusive. The Department maintains the right to approve or deny the nominee based upon the individual's level of experience as it relates to the successful construction and completion of BVW "Compensatory Mitigation Areas". Any change in staffing of the wetland scientist(s) must be approved by the Department per Condition #11 of this Certification.
20. The permittee shall mitigate for all approved fill, dredging, and placement of dredge spoil, either permanent or temporary, within Bordering Vegetated Wetland (BVW) and Isolated Vegetated Wetland (IVW) [as defined at 314 CMR 9.02] at a ratio of at least 1:1 per the requirements of 314 CMR 9.06(2). This mitigation shall be referred to collectively in this Certification as the "BVW Compensatory Mitigation Area". The BVW Compensatory Mitigation Area shall be constructed under the supervision and direction of the wetland scientist(s) per the methodology described in the plan(s) of record listed in the "Findings" section of this Certification, and specifically, the "Wetland Replication Report" prepared by Epsilon Associates, Inc. (hereinafter the "BVW Compensatory Mitigation Area Plan") and attached plan(s) of record. Any deviation from the methodology approved by this Condition of the Certification must be requested in writing and approved by the Department per Condition #11 of this Certification. The proposed "Compensatory Mitigation Area" shall be initially excavated according to the plan(s) of record prior to any earth moving activity otherwise permitted by this Certification. Donor soil placement, organic amendments, and plantings shall not be placed within the BVW Compensatory Mitigation Area until such time as the wetland scientist(s) have verified that the final excavated grade for the said Compensatory Mitigation Area will allow the finished grade of the Compensatory Mitigation Area to be less than or equal to the elevation of the surface of the substrate of the extant and adjoining Bordering Vegetated Wetland, as measured at the interface of the proposed Compensatory

Mitigation Area and the present boundary of said Bordering Vegetated Wetland, and as shown on the plan(s) of record. The wetland scientist(s) shall verify in the field that these elevations will meet the requirements of this Condition. The Department reserves the right to modify the aforementioned "BVW Compensatory Mitigation Area Plan" and any other plan(s) necessary in order to meet the requirements of 314 CMR 9.00, including 314 CMR 9.06(2).

21. Failure to maintain an appropriate standard of care in the installation or post-installation components of required Compensatory Mitigation Area, at any time, including but not limited to planting at inappropriate times of year, failure to reach appropriate subsurface hydrology, failure to restore or replicate suitable substrate conditions, failure to implement standard horticultural practices (such as irrigation, fertilization, disease and pest control), failure to maintain erosion and sedimentation controls, failure to adequately control nonindigenous invasive species, and the loss of plantings of a sufficient number to impair the success of Compensatory Mitigation Area may be deemed noncompliance with this Certification at the sole discretion of the Department, unless identified in writing to the Department by the wetland scientist(s), or the permittee within five (5) business days of discovery. Any such written notification must include a "corrective plan of action", which shall be implemented by the permittee according to a schedule and conditions established in writing by the Department. The Department maintains the right to take enforcement action per 314 CMR 9.11 for any such noncompliance, in addition to its right to require adherence to the several Conditions of this Certification.
22. The Department hereby approves the "Proposed Vegetative Community" specified in "Plant List Wetland-Detail 4" on Sheet E-003 of the Compensatory Mitigation Area Plan. Per Condition #11 of this Certification, any modification of species, ratios, or seeding techniques must be requested by the permittee in writing to the Department and to the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (NHESP-MassDFW); and approved in writing by the Department and NHESP-MassDFW prior to use. Additional applications of an approved seed mix shall be used when appropriate to maintain optimum surficial coverage of vegetation, until such time as the BVW Compensatory Mitigation Area has been fully stabilized and is functioning as BVW, as determined by the wetland scientist(s) per Condition #24 of this Certification.
24. The wetland scientist(s) approved by the Department or their approved designee shall monitor the status of the BVW Compensatory Mitigation Area in calendar years 2022 and 2023, and then until such time as the BVW Compensatory Mitigation Area functions in accordance with 314 CMR 9.06(2), as established by data collected during monitoring. Monitoring shall include, at a minimum, the collection of all data required in pages 1 **and** 2 of "Wetland Determination Data Form – Northcentral and Northeast Region" [as found within US Army Corps of Engineers. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region*, ed. J. S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-12-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center (Version 2.0)]. All vascular plants within the BVW Compensatory Mitigation Area, as shown on the plan(s) of record, shall be identified to the species level. Scientific nomenclature shall follow *The Vascular Plants of Massachusetts: A County Checklist-First Revision*, by Melissa Dow Cullina, Bryan Connolly, Bruce Sorrie and Paul Somers (Massachusetts Natural Heritage & Endangered Species Program, Massachusetts Division of Fish and Wildlife, 2011), or an equivalent acceptable to the Department (as established in writing). At least one (1) "Wetland Determination Data Form"

shall be completed for one distinct "Observation Plot" within the BVW Compensatory Mitigation Area. Sampling shall take place at least once in each growing season in the years specified in this Condition. Each sampling event shall include hydrologic data garnered from "observation holes". These "observation holes" shall be at least twenty-four inches deep, as measured from the surface of the mineral soil horizon. Alternatively, and with the permission of the Department, the wetland scientist(s) or their designee can establish a shallow monitoring well, directly adjacent to the Observation Plot within the BVW Compensatory Mitigation Area. The shallow monitoring wells shall be constructed, installed, and operated in accordance with "Installing Monitoring Wells/Piezometers in Wetlands" [US Army Corps of Engineers, Wetlands Regulatory Assistance Program, WRAP Technical Note ERDC TN-WRAP-00-02, July 2000]. During each sampling event digital color photographs shall be taken of the Observation Plot within the BVW Compensatory Mitigation Area, and of the observation hole established by this Condition. All data collected during each of the years specified in this Condition shall be submitted in a written report entitled "BVW Compensatory Mitigation Area Monitoring Report-Berkshire Line Bridges, Lee and Lenox, Massachusetts". A draft copy shall be submitted to the Department on or before November 30th of each year specified by this Condition. A final copy shall be sent to the Department within thirty (30) calendar days of the receipt of draft comments by the Department, if any.

25. The wetland scientist(s) or their designee shall collect data on wetland hydrology within the BVW Compensatory Mitigation Area at least once per month during the growing season in the years specified at Condition #24. The wetland scientist(s) or their designee shall use the "observation holes" or shallow monitoring wells required by Condition #24 in order to achieve the objectives of this Condition. At a minimum, the wetland scientist(s) or their designee shall record depth to apparent water table and/or depth of surface inundation, both as measured from the soil surface [see *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act* (DEP 1995) for a definition] during each monthly observation. This data shall be included within the report required at Condition #24.
26. Based upon the data collected during sampling events, the wetland scientist(s), or the Department upon its own discretionary initiative, shall render a conclusion within each report required by Condition #24, as to the success of the BVW Compensatory Mitigation Area in terms of 314 CMR 9.06(2), including the establishment of wetland hydrology. If, at the end of the second growing season, the wetland scientist(s), or the Department upon its own discretionary initiative, render a conclusion that the BVW Compensatory Mitigation Area has failed the standards specified at 314 CMR 9.06(2), said wetland scientist(s) shall prepare and submit a written "**corrective plan of action**" no later than the end of that calendar year to the Department for approval. The approved "corrective plan of action" shall be implemented the next growing season under the supervision of a wetland scientist approved by the Department, and shall be monitored via the requirements specified in the several Conditions of this Certification.

Prohibitions and Mitigation for Activities in Land Under Water

27. Activities below the High Water Mark [as defined at 314 CMR 9.02] and within Land Under Water associated with Codding Brook and Willow Creek, shall take place between July 1st and September 30th of any given year. Work within Land Under Water may continue after

September 30th only if the area of proposed work is hydrologically isolated through mechanical means from surface water after June 30th but before October 1st of that year, as confirmed and approved through Condition #11 of this Certification. Any proposed modification under Condition #11 of this Certification not conforming to this Condition of the Certification shall only occur after a written request has been submitted to the Department. The request shall specify the exact position and extent of any proposed in-stream work not in conformance with the above time-of-year (TOY) window; and shall detail why such work must take place outside the specified time period and any additional erosion and sedimentation controls necessary as a result of such proposed work. The Department reserves the right to deny any such request if a practicable alternative exists, as determined solely by the Department.

28. All work upon or within Land Under Water and below the High Water Mark allowed per this Certification shall be accomplished by reference to the plan(s) of record, as modified by the several Conditions of this Certification, if any.
29. Installation of spans, including bridges and open-bottomed arches, and partially embedded culverts within any Land Under Water associated with Codding Brook and permitted by this Certification shall fully comply with 310 CMR 10.54(4)(a)6. and 310 CMR 10.56(4)(a)5. of the Massachusetts Wetlands Protection Act Regulations, and shall be in full compliance with the General Standards in the *Massachusetts River and Stream Crossing Standards* (River and Stream Continuity Partnership, March 1, 2011).
31. The Department has determined that the widening of the bridge crossings of Codding Brook and Willow Creek constitutes additional mitigation for the Aquatic Ecosystem (as defined at 314 CMR 9.02) of these water bodies, in conformance with 314 CMR 9.06(2).
32. Codding Brook and Willow Creek are designated as Coldwater Fish Resources by the Massachusetts Division of Fisheries and Wildlife, and therefore meet the definition of Cold-water Fisheries at 314 CMR 9.02. As such, these reaches are either habitat for brook trout (*Salvelinus fontinalis*) and other coldwater fish species, or consist of habitat potentially viable for brook trout and other coldwater fish species. Therefore, this Certification requires the permittee to notify the Department in writing at least seventy-two (72) hours in advance of any proposed activities with twenty-five (25) feet of the High Water Mark of each of these waterways. The Department reserves the right to require additional protective measures for any work within twenty-five (25) feet of the High Water Mark of these waterways, based upon actual field conditions. Any proposed deviation from this provision must be requested in writing per Condition #11 of this Certification. The Department maintains the right to deny any proposed modifications to this Condition that, in the opinion of the Department, would present short- or long-term adverse affect to the habitat requirements of brook trout, and other cold-water fisheries.
33. The use of geotextiles below the High Water Mark [as defined at 314 CMR 9.02] and within Land Under Water associated with Codding Brook and Willow Creek is prohibited, with the exception that net-less rolled erosion control products may be used where necessary.
34. Between forty (40) calendar days and twenty (20) calendar days prior to the start of any work otherwise permitted by this Certification, the signatory Registered Professional Engineer (RPE) who affixed her/his stamp upon the plan(s) of record shall conduct a site inspection to determine:

a. If the “Ordinary High Water Mark” (“OHWM”, as defined by reference at 314 CMR 9.02), or any other pertinent geomorphic feature of the subject Land Under Water, has moved from the position shown on the plan(s) of record, such that the proposed work cannot be completed according to the plan(s) of record, and/or such that the proposed work would result in a greater areal extent of Discharge to WUSWC than is permitted by this Certification.
b. Within 24 hours of this inspection, the signatory RPE shall submit a written confirmation that the OHWM, nor any other pertinent geomorphic feature, has substantially moved; <u>or</u>
c. The signatory RPE shall alert the Department in writing to any movement that is substantial, and shall propose revisions to the plan(s) of record (and all necessary data, photographs, and analyses) that comply, to the greatest extent practicable, with 314 CMR 9.00 and the several Conditions of this Certification. The Department reserves the right to modify any revised plans submitted under this Condition, at its sole discretion. No work below OHWM is authorized under this Condition until such time as the Department issues authorization to proceed in writing.
d. Upon authorization to proceed, and within twenty-four (24) hours of the initiation of any activity below the OHWM, the signatory RPE shall conduct a final inspection under this Condition to ensure that no high-flow events have resulted in any subsequent substantial movement of the OHWM or other pertinent geomorphic features. Should substantial movement have occurred, the signatory RPE shall immediately notify the Department both electronically and via telephone, and no work is authorized to proceed until the Department issues authorization to proceed in writing.

35. The permittee shall maintain the proposed bridge(s) in working order at all times. Failure to maintain said bridge(s) such that the bridge(s) no longer function as designed; or no longer discharge surface water downstream to other jurisdictional WUSWC (as defined at 314 CMR 9.02) shall not constitute any change to the legal or regulatory status of any jurisdictional WUSWC, either upstream or downstream of said bridge(s), as determined by this Certification. Upon the expiration of this Certification, all jurisdictional WUSWC shall be determined as if the bridge(s) were still properly functioning as required by this Condition. This Condition is ongoing and does not end upon the completion of this project or the expiration of this Certification.

<u>Compliance with Natural Heritage and Endangered Species Program Adverse Affect Determination</u>

36. In accordance with the Department’s responsibilities and authority at 314 CMR 9.06(2), all parties identified at Condition #1 and 3 shall fully comply with all requirements specified within any Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (NHESP-MassDFW) “adverse effect determination” issued for this project. These requirements hereby form a part of, and are inseparable from, this Certification.
37. No work authorized by this Certification may commence until such time as the permittee receives written permission to proceed from NHESP-MassDFW with the initial BVW Compensatory Mitigation Area approved herein, a copy of which shall be sent to the Department. Specifically, the permittee shall receive permission, directives, and instructions concerning surveying from NHESP for and protecting Frank’s lovegrass (*Agrostis frankii*

Meyers.) (Species of Special Concern) and matted spike-sedge (*Eleocharis intermedia* Schult.) (Threatened Species) at or proximate to the BVW Compensatory Mitigation Area at the Hop Brook Wildlife Management Area in Lenox, Massachusetts.

Appeal Rights

Certain persons shall have a right to request an adjudicatory hearing concerning certifications by the Department when an application is required:

a. The applicant or property owner;
b. Any person aggrieved by this certification who has submitted written comments during the public comment period;
c. Any ten (10) citizens of the Commonwealth pursuant to MGL c. 30A where a group member has submitted written comments during the public comment period; or
d. Any governmental body or private organization with a mandate to protect the environment that has submitted written comments during the public comment period.

Any person aggrieved, any ten (10) citizens of the Commonwealth, or a governmental body or private organization with a mandate to protect the environment may appeal without having submitted written comments during the public comment period only when the claim is based on new substantive issues arising from material changes to the scope or impact of the activity and not apparent at the time of public notice. To request an adjudicatory hearing pursuant to MGL c. 30A, § 10, a Notice of Claim to an Adjudicatory Hearing must be made in writing, provided that the request is made by certified mail or hand delivery to the Department, with the appropriate filing fee specified within 310 CMR 4.10 along with a Departmental Action Fee Transmittal Form within twenty-one (21) days from the date of issuance of this Certificate, and addressed to:

Massachusetts Department of Environmental Protection
Case Administrator
One Winter Street, 2nd Floor
Boston, MA 02108

A copy of the request shall at the same time be sent by certified mail or hand delivery to the issuing office of the Wetlands and Waterways Program at:

Massachusetts Department of Environmental Protection
Springfield State Office Building
436 Dwight Street
Springfield, MA 01103

A Notice of Claim for Adjudicatory Hearing shall comply with the Department's Rules for Adjudicatory Proceedings, 310 CMR 1.01(6), and shall contain the following information pursuant to 310 CMR 4.10(3):

a. The §401 Certification Transmittal Number and DEP Wetlands Protection Act File Number;
b. The complete name of the applicant and address of the project;
c. The complete name, address, and facsimile and telephone numbers of the party filing the request, and, if represented by counsel or other representative, the name, facsimile and telephone numbers, and address of the attorney;
d. If claiming to be a party aggrieved, the specific facts that demonstrate that the party satisfies the definition of "aggrieved person" found at 314 CMR 9.02;
e. A clear and concise statement that an adjudicatory hearing is being requested;
f. A clear and concise statement of (1) the facts which are grounds for the proceedings, (2) the objections to this Certificate, including specifically the manner in which it is alleged to be inconsistent with the Department's Water Quality Regulations, 314 CMR 9.00, and (3) the relief sought through the adjudicatory hearing, including specifically the changes desired in the final written Certification; and
g. A statement that a copy of the request has been sent by certified mail or hand delivery to the applicant, the owner (if different from the applicant), the conservation commission of the city or town where the activity will occur, the Massachusetts Department of Conservation and Recreation (when the Certificate concerns projects in Areas of Critical Environmental Concern), the public or private water supplier where the project is located (when the certificate concerns projects in Outstanding Resource Waters), and any other entity with responsibility for the resource where the project is located.

<u>The hearing request along with a Departmental Action Fee Transmittal Form and a valid check or money order payable to the Commonwealth of Massachusetts in the amount of one hundred dollars ($100) must be mailed to:</u>

Commonwealth of Massachusetts
Department of Environmental Protection
Commonwealth Master Lockbox
Post Office Box 4062
Boston, MA 02211

The request will be dismissed if the filing fee is not paid, unless the appellant is exempt or granted a waiver. The filing fee is not required if the appellant is a city or town (or municipal agency), county, or district of the Commonwealth of Massachusetts, or a municipal housing authority. The Department may waive the adjudicatory-hearing filing fee pursuant to 310 CMR 4.06(2) for a person who shows that paying the fee will create an undue financial hardship. A person seeking a waiver must file an affidavit setting forth the facts believed to support the claim of undue financial hardship together with the hearing request as provided above.

If you have further questions regarding this Certification, please contact me at David.Cameron@mass.gov.

Sincerely,

/s/ *David Cameron*

David Cameron, PWS
Chief, Division of Wetlands and Waterways

W:/…MassDOT-RTD X287167 WQC.docx

ISSUED ELECTRONICALLY ONLY

ec: Lee Conservation Commission
concom@town.lee.ma.us

Lenox Conservation Commission

Alyssa Jacobs, PWS, Associate & Manager, Ecological Sciences
Epsilon Associates, Inc.
ajacobs@epsilonassociates.com

Paul Maniccia, Supervisor
Regulatory Division, Permits and Enforcement Branch A
United States Department of the Army
New England District, Corps of Engineers
Paul.M.Maniccia@usace.army.mil

David Paulson, Endangered Species Review Biologist
Natural Heritage and Endangered Species Program of the
Massachusetts Division of Fisheries and Wildlife
David.Paulson@mass.gov

From: Gruszkos, Thomas (DEP) <thomas.gruszkos@state.ma.us>
Sent: Wednesday, August 24, 2022 3:01 PM
To: Alyssa Jacobs; Conti, Scott (DOT)
Cc: Foulis, David (DEP); Wu, June Qun; concom@town.lee.ma.us; paul.m.maniccia@usace.army.mil; Paulson, David (FWE)
Subject: RE: ISSUANCE of Water Quality Certification---Transmittal #X287167---Berkshire Line Bridges Replacement Project, Towns of Lee and Lenox, MA
Attachments: DEP Letter CFT 05312022.pdf

PLEASE Acknowledge receipt of this correspondence by return e-mail

THIS ELECTRONIC CORRESPONDENCE HEREBY FORMS AN INTEGRAL AND INSEPARABLE PART OF THE ABOVE-REFERENCED WATER QUALITY CERTIFICATION. PLEASE RETAIN A HARDCOPY IN YOUR PERMANENT RECORDS

RE: Water Quality Certification for Bridge Maintenance on Bridges at MP77.16 and MP79.90, Codding Brook and Willow Creek, Lee and Lenox, MA Transmittal #X287167

Ms. Jacobs:

In accordance with its authority at Condition # 11 of the above-referenced Water Quality Certification (WQC) the Massachusetts Department of Environmental Protection (MassDEP) hereby approves the proposed substitution of the siltation controls identified in Condition 17 of the above referenced WQC, with 12-inch (or greater) Compost Filter Tubes (CFTs), subject to the following conditions:

1. All CFTs shall be, at minimum, 12-inches in diameter;
2. Land surfaces shall be prepared in a manner that ensures that the CFT makes sufficient ground contact so that no untreated stormwater flows under the CFT;
3. CFTs shall not be used as a perimeter control in areas of concentrated flows unless additional support is provided with silt fence;
4. Sediment shall be removed once it reaches half the height of the CFT;
5. The CFT shall be inspected daily, no later than 9:00 am, to ensure proper function and performance of the CFT;
6. CFT maintenance and replacement identified during the daily inspection shall be fixed no later than 11:00am on the same workday that the issue was identified;
7. A CFT maintenance log shall be filled out daily and shall briefly identifies the issue(s), location(s), and corrective action(s);
8. Record of the CFT maintenance logs shall be kept onsite throughout the duration of the Project and shall be made available within a reasonable period of time, but no later than two (2) business days, upon the request of MassDEP;

9. The CFTs that require frequent repair or replacement must be evaluated to determine if the controls are adequate, and improvements to the erosion and sedimentation control Best Management Practices (BMPs) shall be implemented as necessary to protect public health or maintain the chemical, physical, and biological integrity of the water resources of the Commonwealth;
10. The MassDEP has the right to require additional controls if they determine that the existing erosion and sedimentation control BMPs are not adequate for protecting the public health or maintaining the chemical, physical, and biological integrity of the water resources of the Commonwealth; and
11. Compliance with this approval does not relieve the permittee or any other person or party of the necessity of complying with all other Conditions of the Water Quality Certification (Transmittal No. X287167).

Please do not hesitate to contact me if you have any questions, comments or concerns.

Regards,

Tom Gruszkos
Division of Wetlands and Waterways
MassDEP – Western Regional Office
436 Dwight Street
Springfield, MA 01103
Office: 413-755-2260 | Mobile (preferred): 617-352-2064
Email: thomas.gruszkos@mass.gov

From: Alyssa Jacobs <AJacobs@epsilonassociates.com>
Sent: Tuesday, May 31, 2022 5:07 PM
To: Gruszkos, Thomas (DEP) <thomas.gruszkos@mass.gov>
Cc: Foulis, David (DEP) <david.foulis@mass.gov>; Wu, June Qun <June.Wu@hdrinc.com>
Subject: RE: ISSUANCE of Water Quality Certification---Transmittal #X287167---Berkshire Line Bridges Replacement Project, Towns of Lee and Lenox, MA

Tom,

I've attached a revised letter as well as the research detailing the efficacy of compost filter tubes

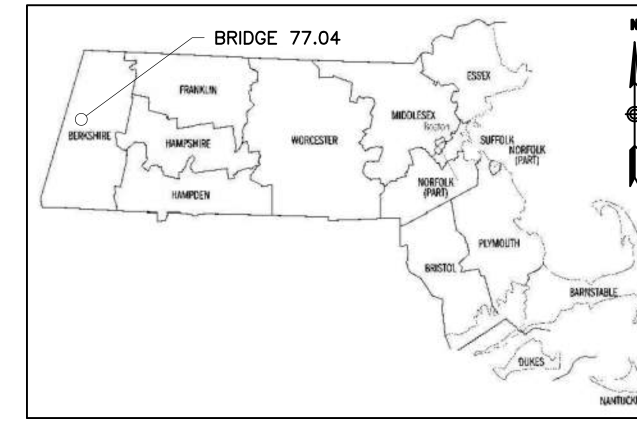
Alyssa Jacobs, PWS
Principal & Manager, Ecological Sciences

Epsilon Associates, Inc.

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
RAIL & TRANSIT DIVISION

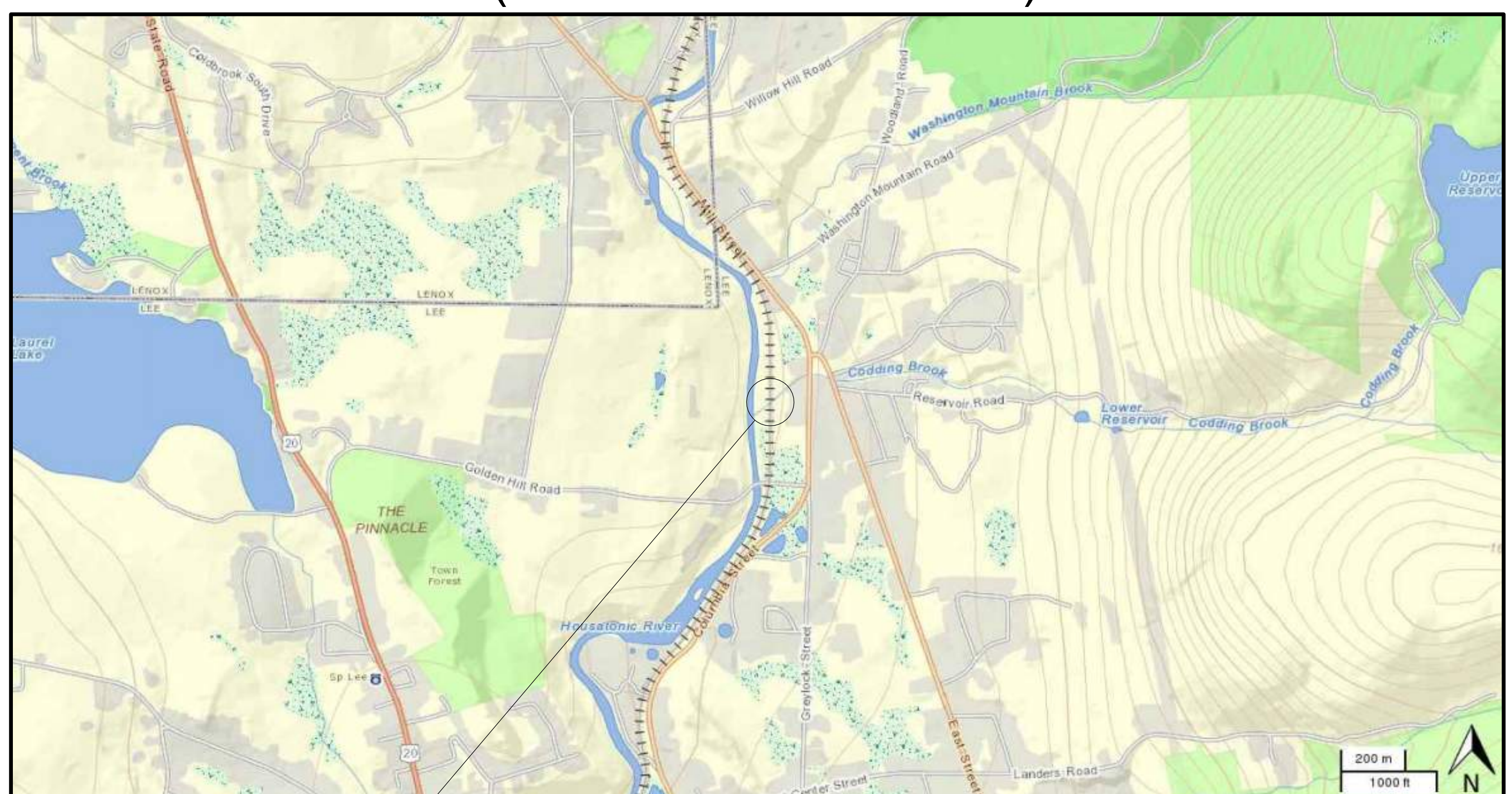
REPLACEMENT OF BERKSHIRE LINE BRIDGE NO.77.04

PROJECT LOCATION: LEE, MA



LOCATION MAP

PERMIT PLANS - 02/12/2021
(REVISED 10/25/2021)



PLAN

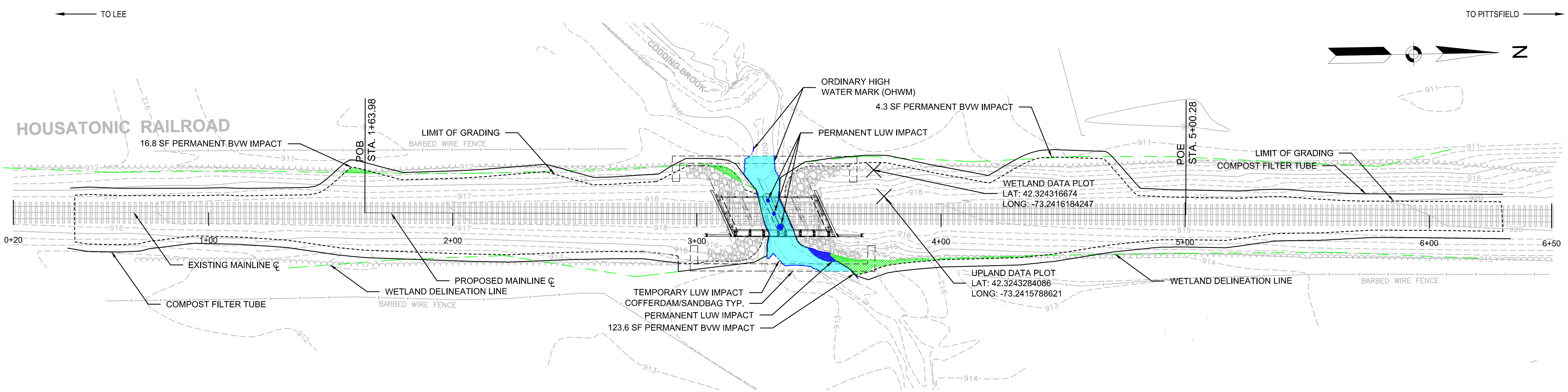
REPLACEMENT OF BRIDGES ON BERKSHIRE LINE
BRIDGE 77.04 – CODDING BROOK BRIDGE
SHEET 1 OF 4

ISSUE	DATE	DESCRIPTION	BY	CHK'D	APP.
	10/25/21	SECOND REVISION			
	02/12/21	FIRST REVISION			
	12/29/20	ORIGINAL PLANS			

HDR, INC.
99 HIGH STREET, SUITE 2300
BOSTON, MA 02110
(617) 357-7700

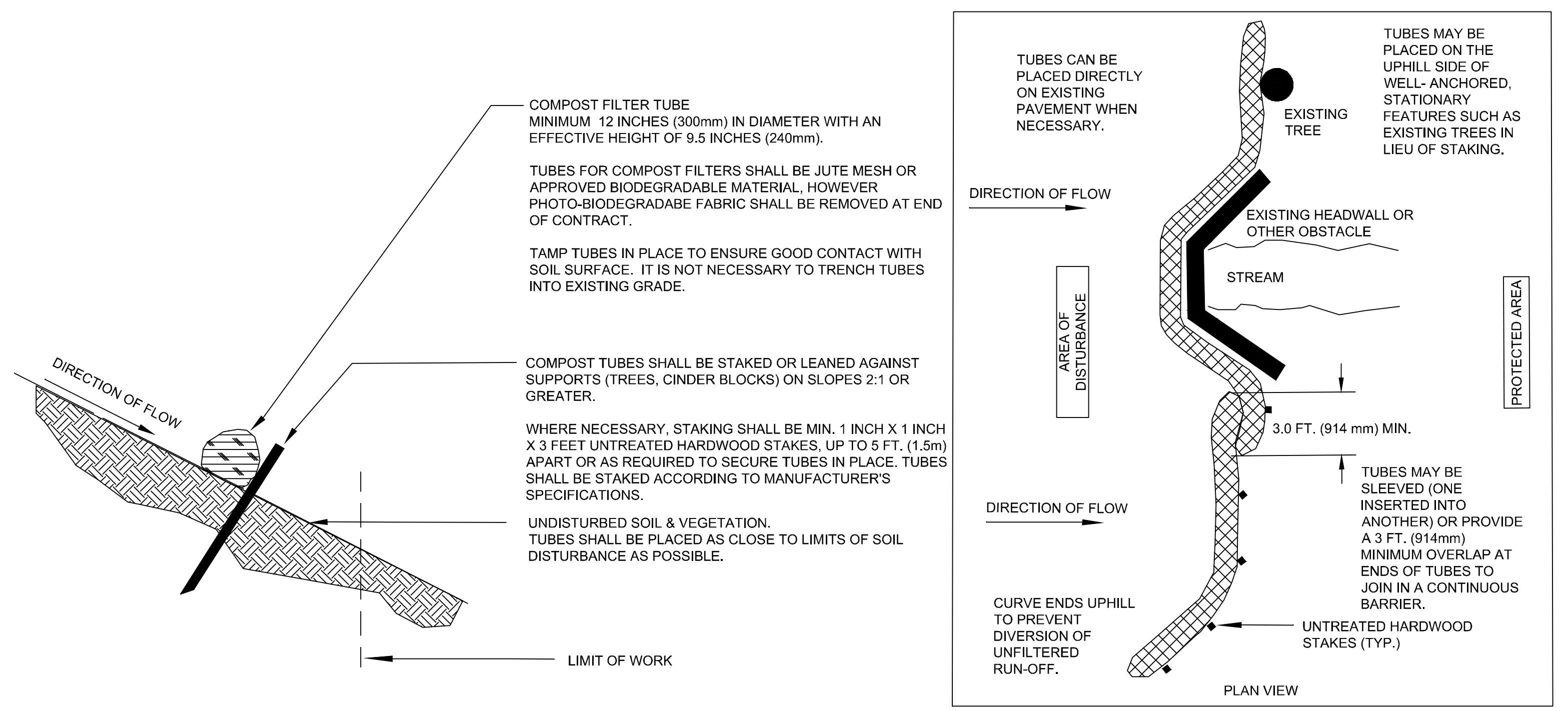
massDOT Massachusetts Department of Transportation Rail & Transit Division

SCALE: AS NOTED	DRAWN BY	DESIGN BY	CHECK BY	PLAN NO.	ISSUE
DATE: 02/12/2021	SSL	SSL	JQW	SHEET:	



PLAN

SCALE: 1" = 40' @ 11" BY 17"



COMPOSITE FILTER TUBE DETAILS

NOT TO SCALE

IMPACT AREAS		
DESCRIPTION	TOTAL AREA (SF)	DREDGING (CF)
BORDERING VEGETATED WETLAND (EMBANKMENT)	188	-
TEMPORARY LAND UNDER WATER (COFFERDAM)	583	-
PERMANENT LAND UNDER WATER (PILES)	8	-
PERMANENT LAND UNDER WATER (RIPRAP)	27	79

NOTES:

1. PROVIDE A MINIMUM TUBE DIAMETER OF 12 INCHES (300mm) FOR SLOPES OF UP TO 50 FT (15.24m) IN LENGTH WITH A SLOPE RATIO OF 3H:1V OR STEEPER. LONGER SLOPES OF 3H:1V MAY REQUIRE LARGER TUBE DIAMETER OR ADDITIONAL COURSING OF FILTER RUBES TO CREATE A FILTER BERM. REFER TO MANUFACTURER'S RECOMMENDATIONS FOR SITUATIONS WITH LONGER OR STEEPER SLOPES.
2. INSTALL TUBES ALONG CONTOURS AND PERPENDICULAR TO SHEET OR CONCENTRATED FLOW.
3. TUBE LOCATION MAY BE SHIFTED TO ADJUST TO LANDSCAPE FEATURES, BUT SHALL PROTECT UNDISTURBED AREA AND VEGETATION TO MAXIMUM EXTENT POSSIBLE.
4. DO NOT INSTALL IN PERENNIAL, EPHEMERAL OR INTERMITTENT STREAMS.
5. ADDITIONAL TUBES SHALL BE USED AT THE DIRECTION OF THE ENGINEER.
6. ADDITIONAL STAKING SHALL BE USED AT THE DIRECTION OF THE ENGINEER.

LEGEND

PERMANENT BORDERING VEGETATED WETLAND IMPACT AREA

TEMPORARY LAND UNDER WATER IMPACT AREA

PERMANENT LAND UNDER WATER IMPACT AREA

0 20 50 100

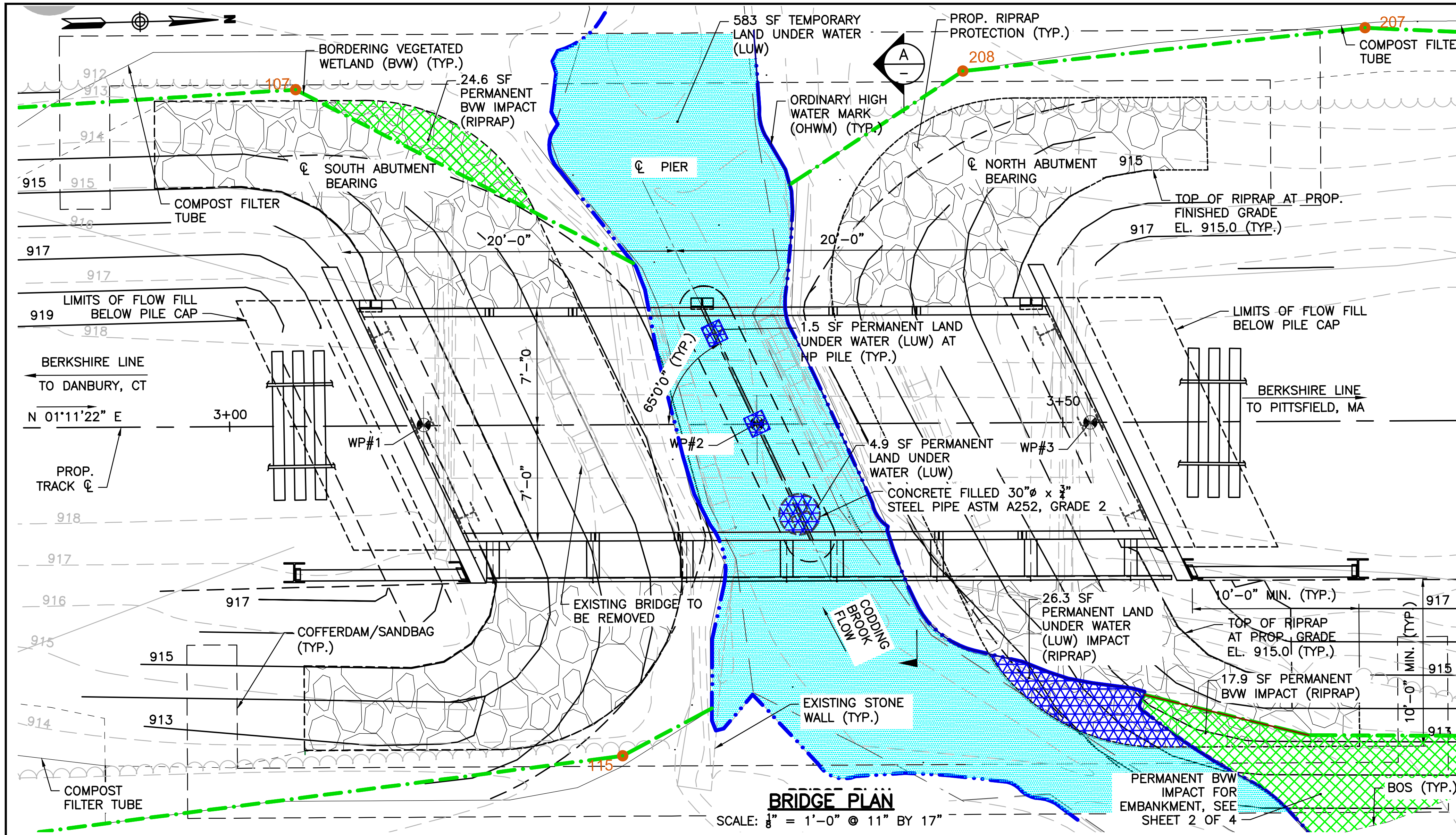
SCALE: 1" = 40' @ 11" BY 17"

SECOND REVISION DATE: OCTOBER 25, 2021

FIRST REVISION DATE: FEBRUARY 12, 2021

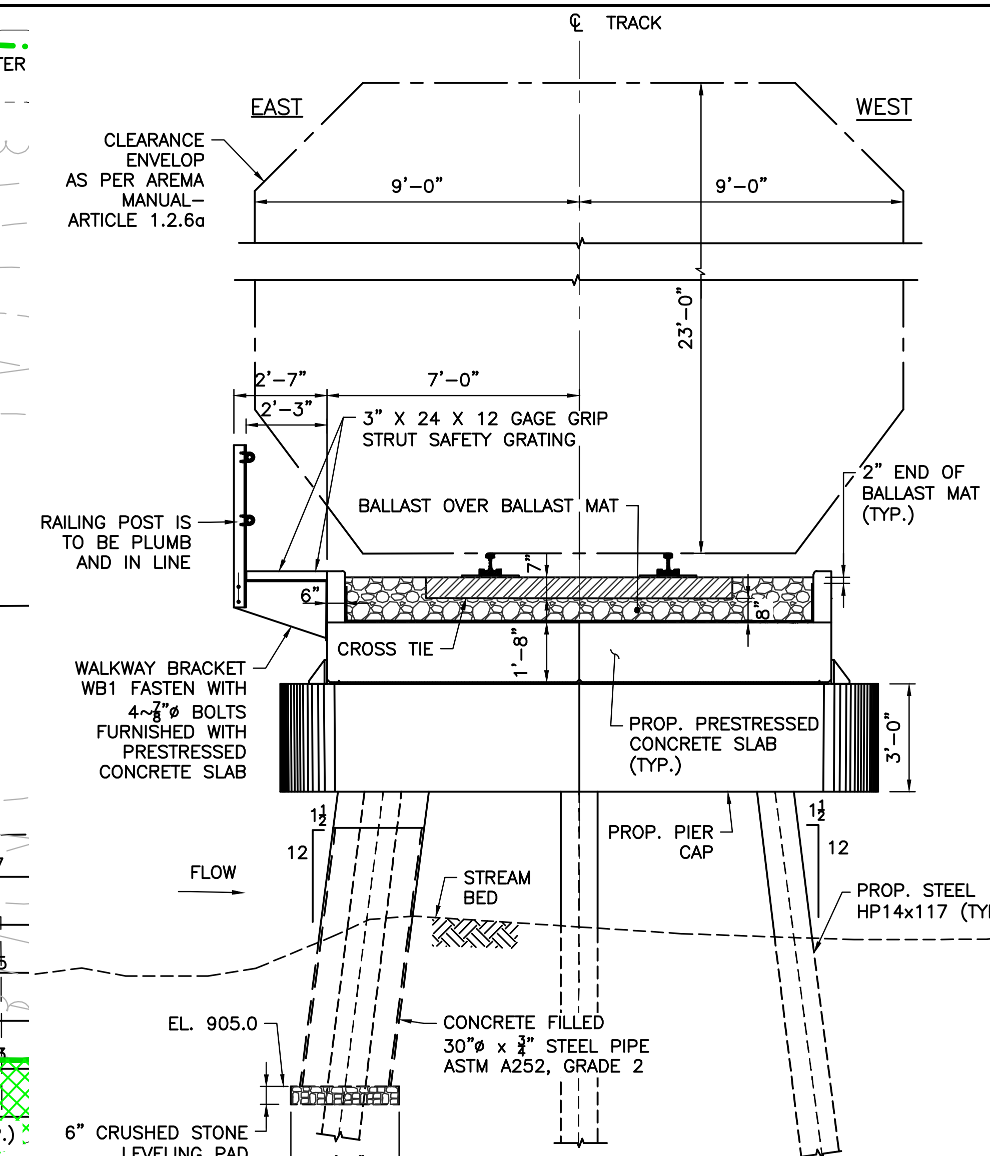
ORIGINAL PLAN DATE: DECEMBER 29, 2020

SHEET 2 OF 4



BRIDGE PLAN

SCALE: 1/8" = 1'-0" @ 11" BY 17"



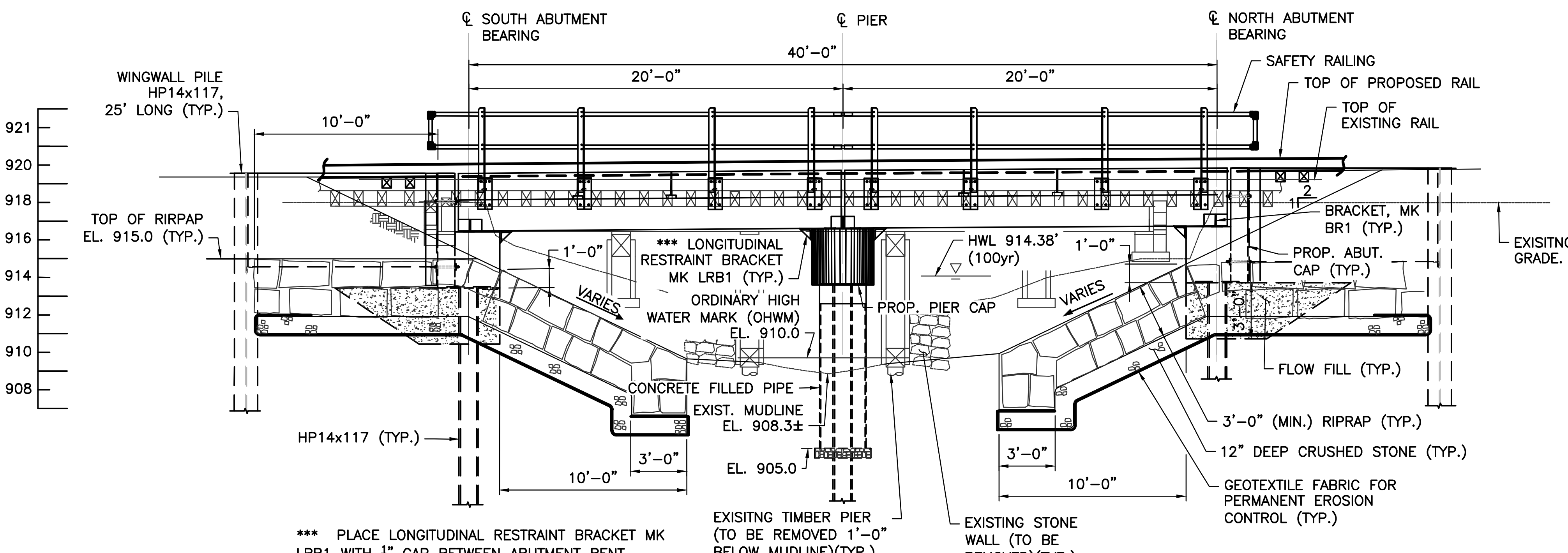
SECTION A

SCALE: 3/16" = 1'-0" @ 11" BY 17"

WP#	STATION	NORTHING	EASTING	ELEVATION (TOP OF RAIL)
1	3+11.65	2947956.4076	185237.1596	920.06'
2	3+31.65	2947976.4032	185237.5748	920.22'
3	3+51.65	2947996.3989	185237.9899	920.34'

NOTES:

1. GENERAL NOTES REFFER TO DWG NO. S-1.
2. W.P ELEVATIONS CORRESPOND TO THE ELEVATION OF THE TOP OF THE RAIL AT STATION INDICATED.
3. FILL GAP BETWEEN ENDS OF BEAMS AND FACE OF BACKWALL WITH PILES OF PREFORMED JOINT FILLER.

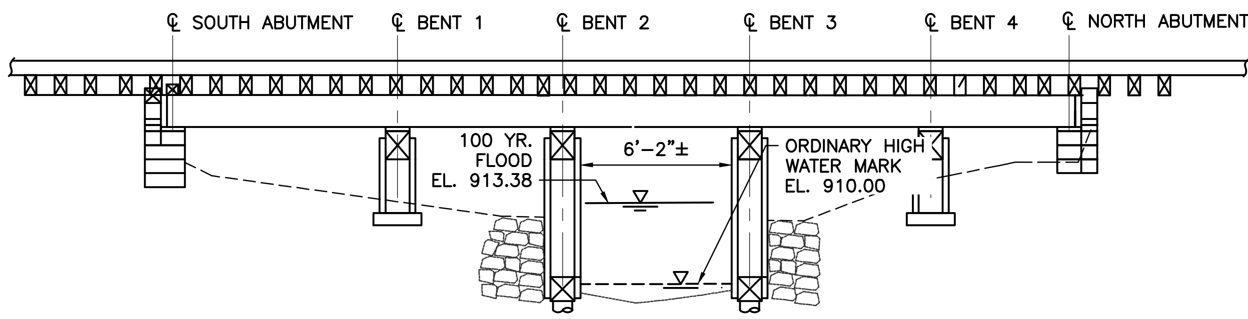


*** PLACE LONGITUDINAL RESTRAINT BRACKET MK LRB1 WITH 1/4" GAP BETWEEN ABUTMENT BENT CAPS/CENTER BENT CAP AND BRACKET AND 5/16" FIELD FILLET WELD TO PLATE IN BOTTOM OF BEAM.

ELEVATION

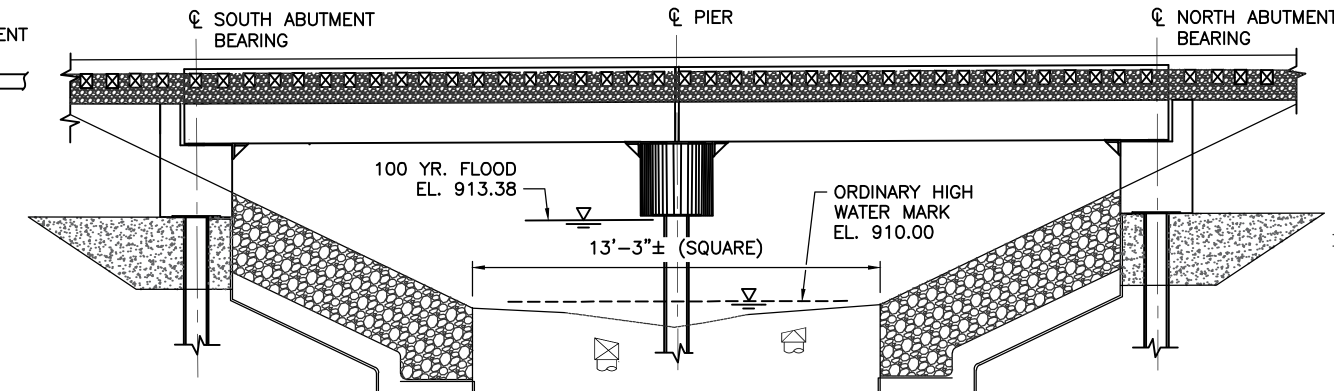
SCALE: 1/8" = 1'-0" @ 11" BY 17"

SECOND REVISION DATE: OCTOBER 25, 2021
FIRST REVISION DATE: FEBRUARY 12, 2021
ORIGINAL PLAN DATE: DECEMBER 29, 2020



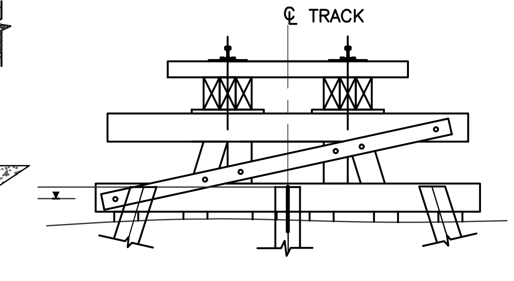
EXISTING

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



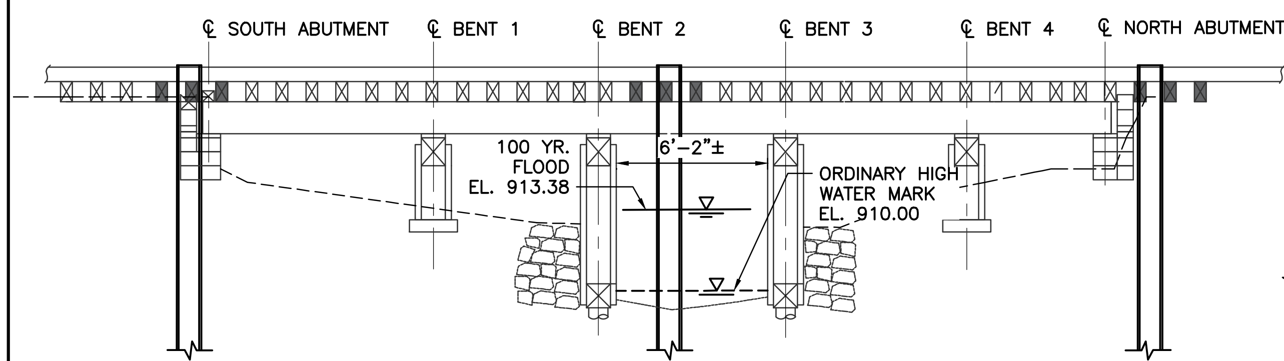
STAGE 3

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



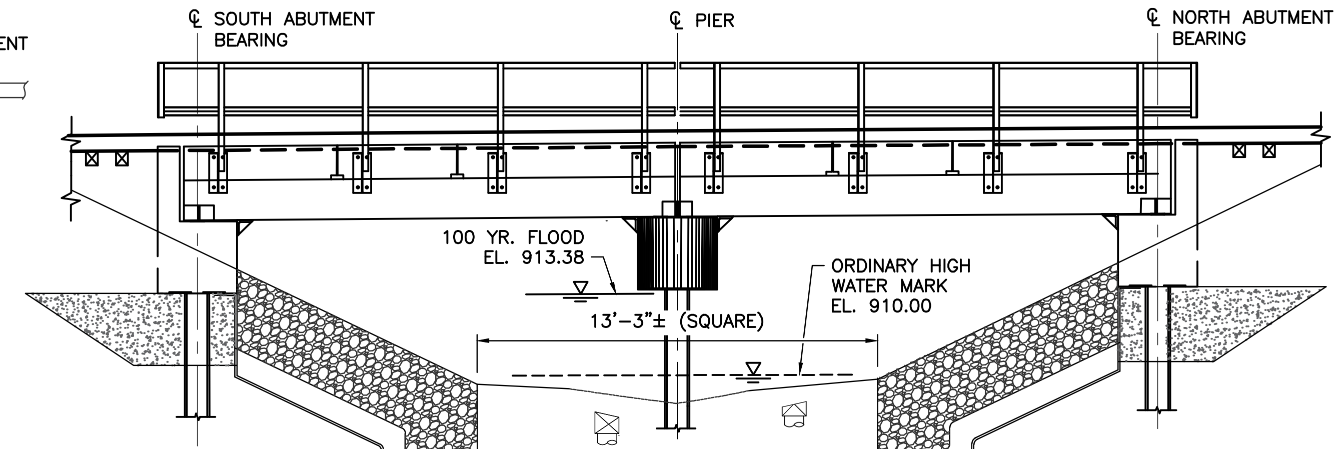
SECTION A

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



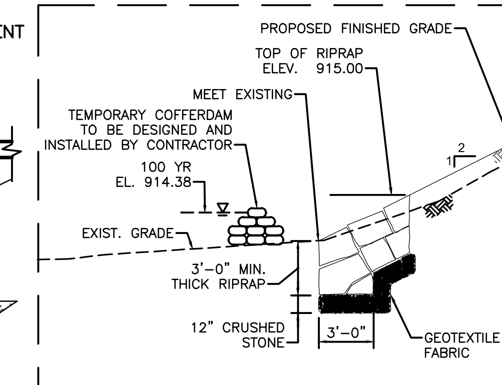
STAGE 1

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



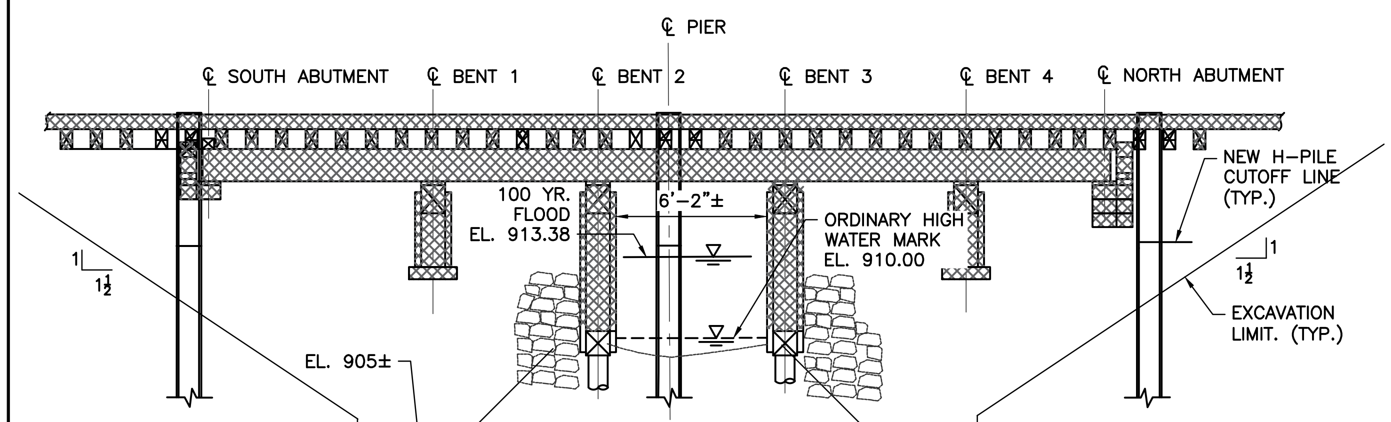
FINAL

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



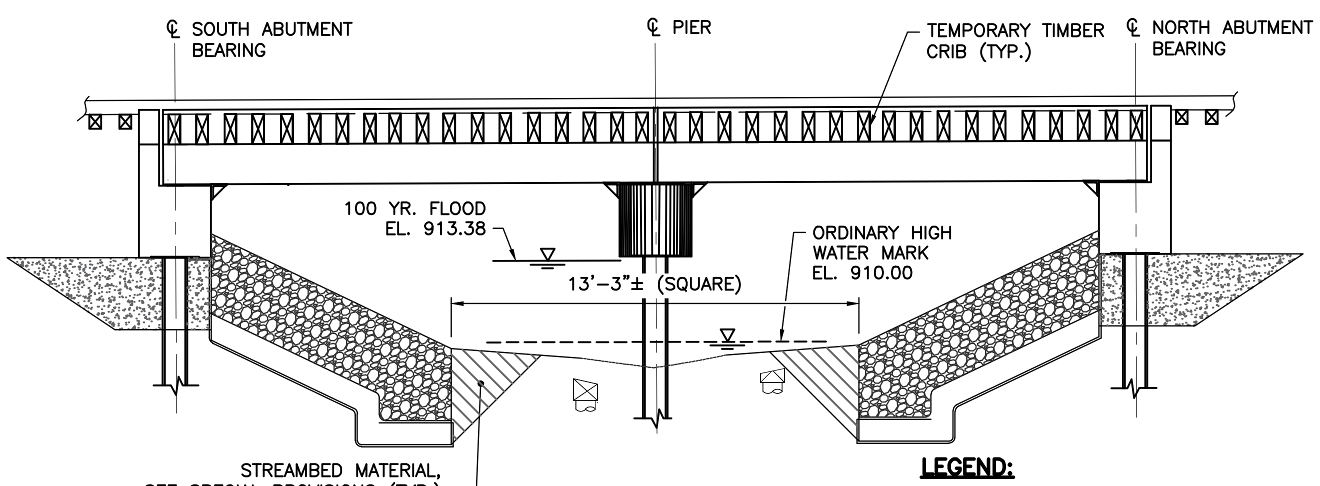
COFFERDAM DETAIL SECTION

SCALE: $\frac{3}{32}$" = 1'-0" @ 11" BY 17"



STAGE 2A

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"



STAGE 2B

SCALE: $\frac{1}{8}$" = 1'-0" @ 11" BY 17"

LEGEND:

TEMPORARY REMOVAL DURING STAGING

EXISTING STRUCTURE REMOVAL

SUGGESTED CONTRUCTION STAGING:

STAGE 1 – H-PILE PRE-INSTALLATION

WORKING HOURS SHALL BE DURING NON-TRAIN OPERATION HOURS OR DURING A WEEKEND CLOSING.

1. REMOVE EXISTING WOODEN TIES TEMPORALLY TO FACILITATE THE INSTALLATION OF H-PILES.
2. INSTALL H-PILES FOR THE NEW STRUCTURE, ONE PIER/ABUTMENT LOCATION AT A TIME.

STAGE 2 – COFFERDAM INSTALLATION AND BRIDGE REPLACEMENT

WORKING HOURS SHALL BE DURING A WEEKEND CLOSURE.

1. COFFERDAM TO BE DESIGNED AND INSTALLED BY THE CONTRACTOR PRIOR TO EXISTING SUBSTRUCTURE REMOVAL.
2. CONTRACTOR SHALL MAINTAIN THE WORK AREA IN DRY CONDITION DURING CONSTRUCTION.

STAGE 2A – REMOVAL

1. REMOVAL OF EXISTING SUPERSTRUCTURE INCLUDING EXISTING TIES AND RAILS.
2. REMOVAL OF EXISTING TIMBER BENTS AND ABUTMENTS. TIMBER PILES ABOVE THE GROUND LINE SHALL BE CUT AND REMOVED 1 FEET BELOW GROUND. THE EXISTING TIMBER PILES BELOW GROUND SHALL REMAIN IN PLACE.
3. REMOVE EXISTING STONE RETAINING WALLS.
4. DEWATER AND EXCAVATE THE EXISTING GROUND FOR THE EMBANKMENT PROTECTION AND NEW ABUTMENTS.

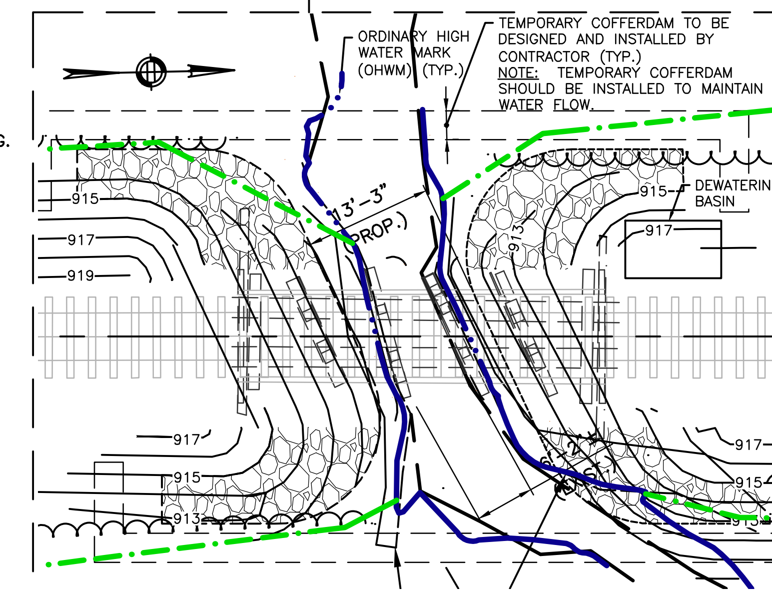
STAGE 2B – BRIDGE INSTALLATION

1. INSTALL GEOTEXTILE FABRIC, CRUSHED STONE, AND RIPRAP IN FRONT OF THE ABUTMENTS ONLY UP TO THE BOTTOM OF EXCAVATION FOR THE ABUTMENT CAPS, PRIOR TO THE INSTALLATION OF THE ABUTMENT CAPS.
2. INSTALL AND WELD THE NEW PRECAST ABUTMENTS, PIER CAP AND WINGWALLS TO THE PRE-INSTALLED H-PILES.
3. FINISH PLACING GEOTEXTILE FABRIC, CRUSHED STONE, AND RIPRAP IN FRONT OF THE ABUTMENTS AND PLACE FLOW FILL BELOW ABUTMENTS.
4. INSTALL NEW SUPERSTRUCTURE.
5. AFTER FLOW FILL HARDENS, PLACE AND COMPACT BACKFILL BEHIND BOTH ABUTMENTS SHALL BE PLACED SIMULTANEOUSLY.
6. INSTALL BEARINGS TO THE ABUTMENT CAPS AND PIERS CAP.
7. INSTALL TEMPORARY TIMBER CRIBS AND RAILS.
8. OPEN BRIDGE TO TRAIN SERVICE.

STAGE 3 – RAISE OF TRACK PROFILE
FINAL BRIDGE INSTALLATION

WORKING HOURS SHALL BE DURING A WEEKEND CLOSURE.

1. REMOVE TEMPORARY TIMBER CRIBS AND RAILS.
2. PERFORM TRACK WORK ON BRIDGE APPROACHES.
3. INSTALL BALLAST MAT, BALLAST, CROSS TIES AND RAILS.
4. INSTALL STEEL HAND RAILINGS.
5. INSTALL GEOTEXTILE, CRUSHED STONE AND RIPRAP TO THE REMAINING AREAS.
6. OPEN TRACK AND BRIDGE TO TRAIN SERVICE.



TEMPORARY COFFERDAM PLAN

SCALE: 1" = 20'-0" @ 11" BY 17"

TEMPORARY SUPPORT NOTE:

TEMPORARY TRACK SUPPORT AT ABUTMENTS SHALL BE DESIGNED AND FABRICATED BY THE CONTRACTOR PRIOR TO CONSTRUCTION IN CASE EXISTING ABUTMENTS ARE DAMAGED DURING INSTALLATION OF PILES. DESIGN OF TEMPORARY SUPPORT SHALL BE STAMPED BY A PROFESSIONAL STRUCTURAL ENGINEER REGISTERED IN THE COMMONWEALTH OF MASSACHUSETTS AND SUBMITTED TO THE ENGINEER FOR REVIEW AND APPROVAL BEFORE FABRICATION. COST OF TEMPORARY SUPPORT SHALL BE INCIDENTAL TO PILE INSTALLATION.

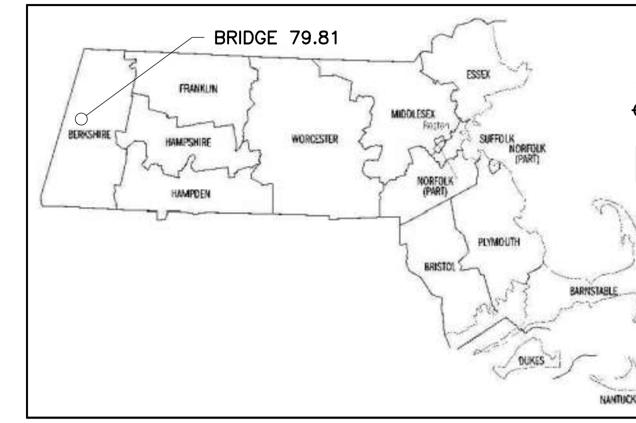
SECOND REVISION DATE: OCTOBER 25, 2021
FIRST REVISION DATE: FEBRUARY 12, 2021
ORIGINAL PLAN DATE: DECEMBER 29, 2020

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
RAIL & TRANSIT DIVISION

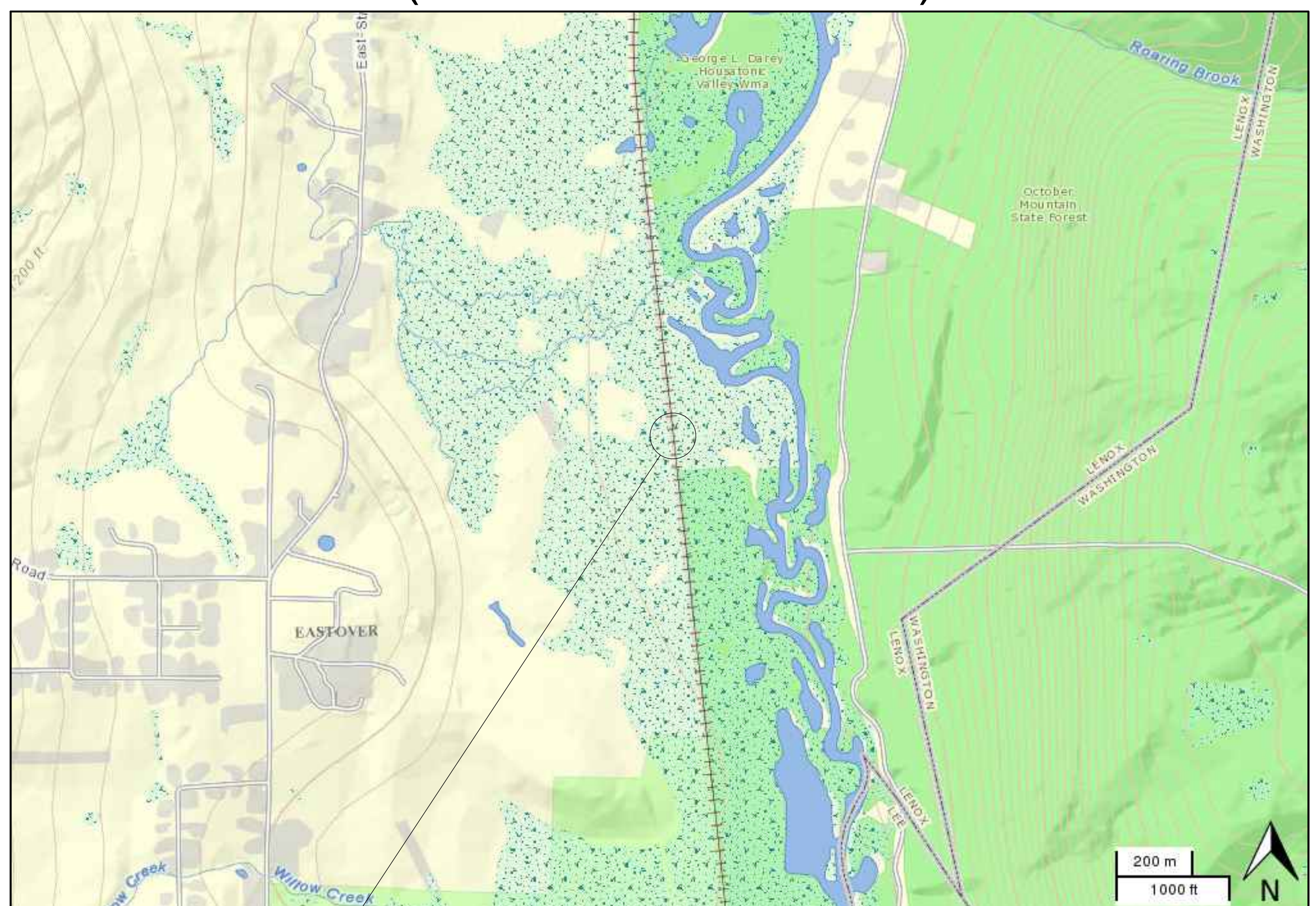
REPLACEMENT OF BERKSHIRE LINE BRIDGE NO.79.81

PROJECT LOCATION: LENOX, MA

PERMIT PLANS - 02/12/2021
(REVISED 10/25/2021)



LOCATION MAP



BRIDGE 79.81

PLAN

REPLACEMENT OF BRIDGES ON BERKSHIRE LINE
BRIDGE 79.81 – WILLOW CREEK BRIDGE
SHEET 1 OF 4

HDR, INC.
99 HIGH STREET, SUITE 2300
BOSTON, MA 02110
(617) 357-7700

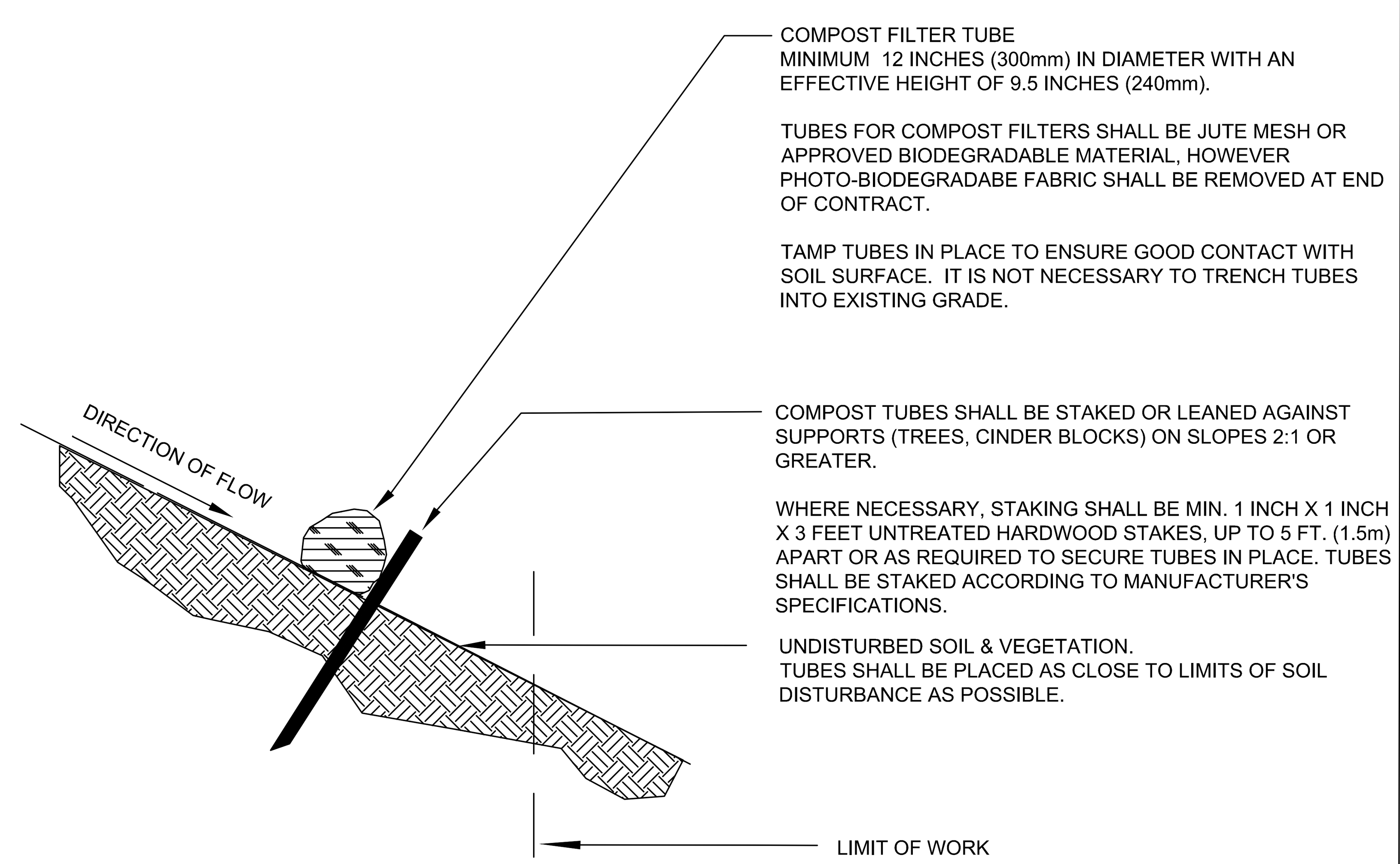
Massachusetts Department of Transportation
Rail & Transit Division

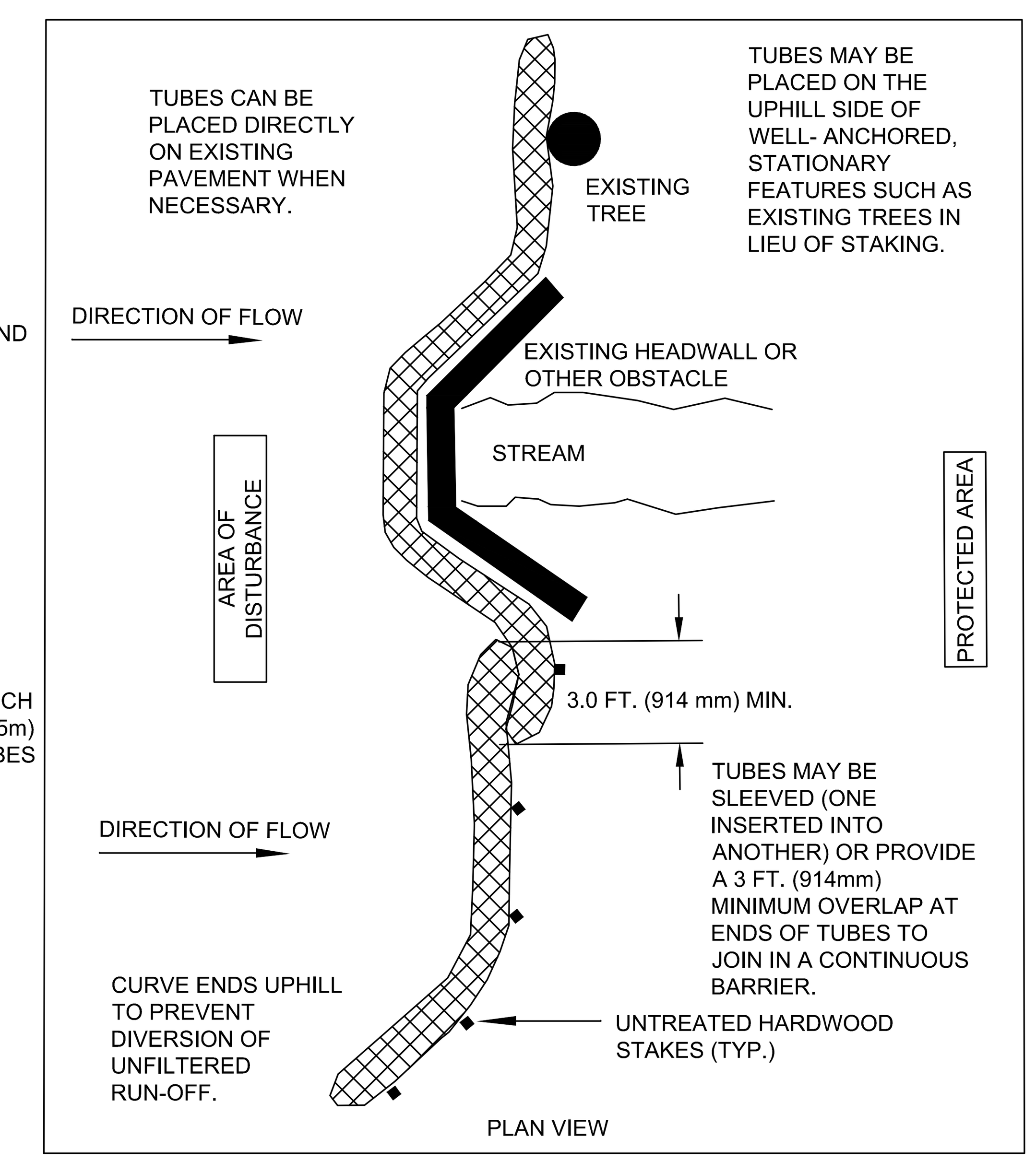
ISSUE	DATE	DESCRIPTION	BY	CHK'D	APP.
	10/25/21	SECOND REVISION			
	02/12/21	FIRST REVISION			
	12/29/20	ORIGINAL PLANS			

SCALE: AS NOTED	DRAWN BY	DESIGN BY	CHECK BY	PLAN NO.	ISSUE
DATE: 02/12/2021	SSL	SSL	JQW	SHEET: XX	

PLAN

SCALE: 1" = 40' @ 11" BY 17"





COMPOSITE FILTER TUBE DETAILS

NOT TO SCALE

LEGEND

PERMANENT BORDERING VEGETATED WETLAND IMPACT AREA

TEMPORARY LAND UNDER WATER IMPACT AREA

PERMANENT LAND UNDER WATER IMPACT AREA

IMPACT AREAS	
DESCRIPTION	TOTAL AREA (SF)
BORDERING VEGETATED WETLAND (EMBANKMENT)	246
TEMPORARY LAND UNDER WATER (COFFERDAM)	742
PERMANENT LAND UNDER WATER (PILES)	8

NOTES:
1. PROVIDE A MINIMUM TUBE DIAMETER OF 12 INCHES (300mm) FOR SLOPES OF UP TO 50 FT (15.24m) IN LENGTH WITH A SLOPE RATIO OF 3H:1V OR STEEPER. LONGER SLOPES OF 3H:1V MAY REQUIRE LARGER TUBE DIAMETER OR ADDITIONAL COURSING OF FILTER TUBES TO CREATE A FILTER BERM. REFER TO MANUFACTURER'S RECOMMENDATIONS FOR SITUATIONS WITH LONGER OR STEEPER SLOPES.
2. INSTALL TUBES ALONG CONTOURS AND PERPENDICULAR TO SHEET OR CONCENTRATED FLOW.
3. TUBE LOCATION MAY BE SHIFTED TO ADJUST TO LANDSCAPE FEATURES, BUT SHALL PROTECT UNDISTURBED AREA AND VEGETATION TO MAXIMUM EXTENT POSSIBLE.
4. DO NOT INSTALL IN PERENNIAL, EPHEMERAL OR INTERMITTENT STREAMS.
5. ADDITIONAL TUBES SHALL BE USED AT THE DIRECTION OF THE ENGINEER.
6. ADDITIONAL STAKING SHALL BE USED AT THE DIRECTION OF THE ENGINEER.

0 20 50 100

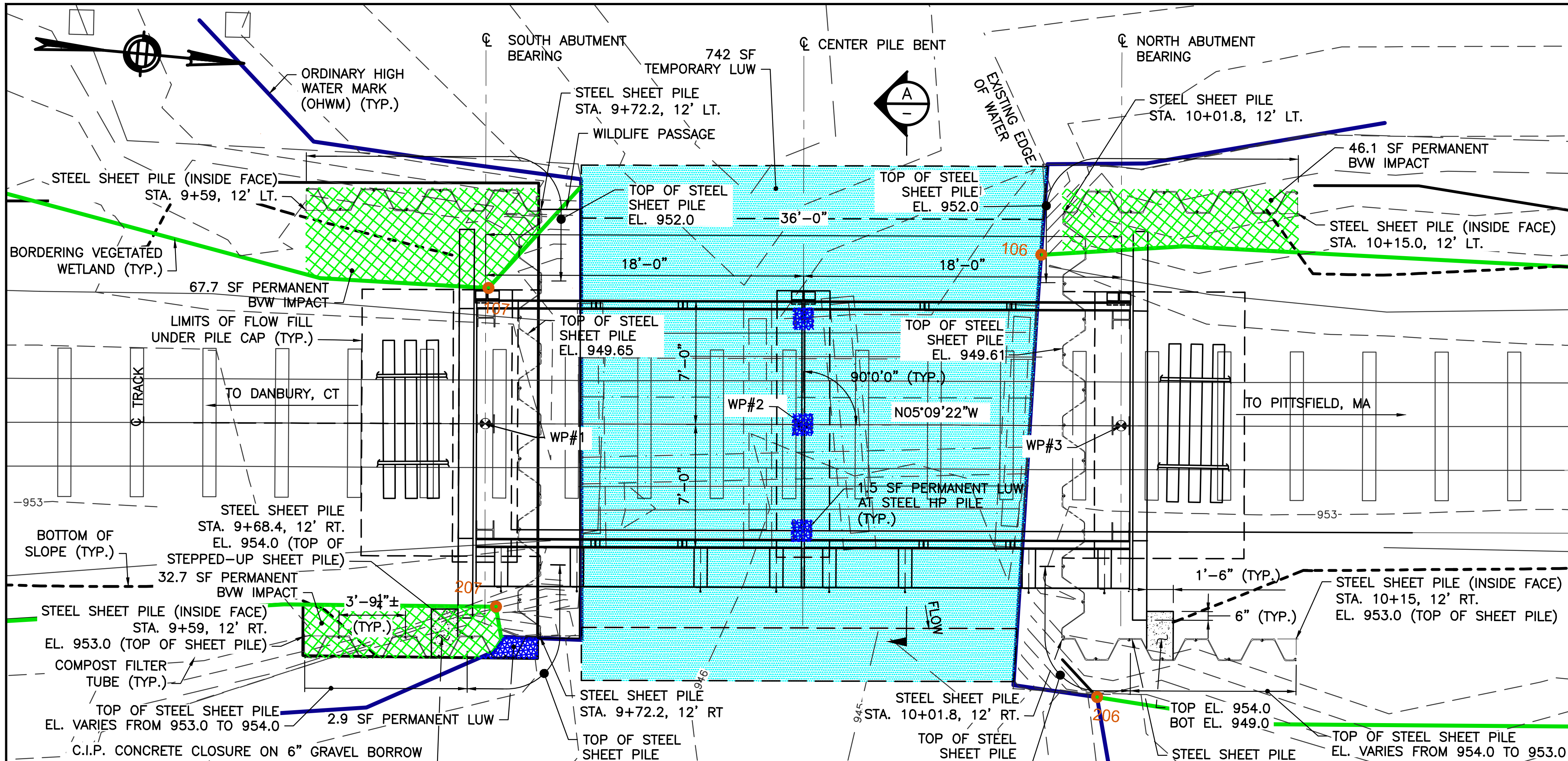
SCALE: 1" = 40' @ 11" BY 17"

SECOND REVISION DATE: OCTOBER 25, 2021

FIRST REVISION DATE: FEBRUARY 12, 2021

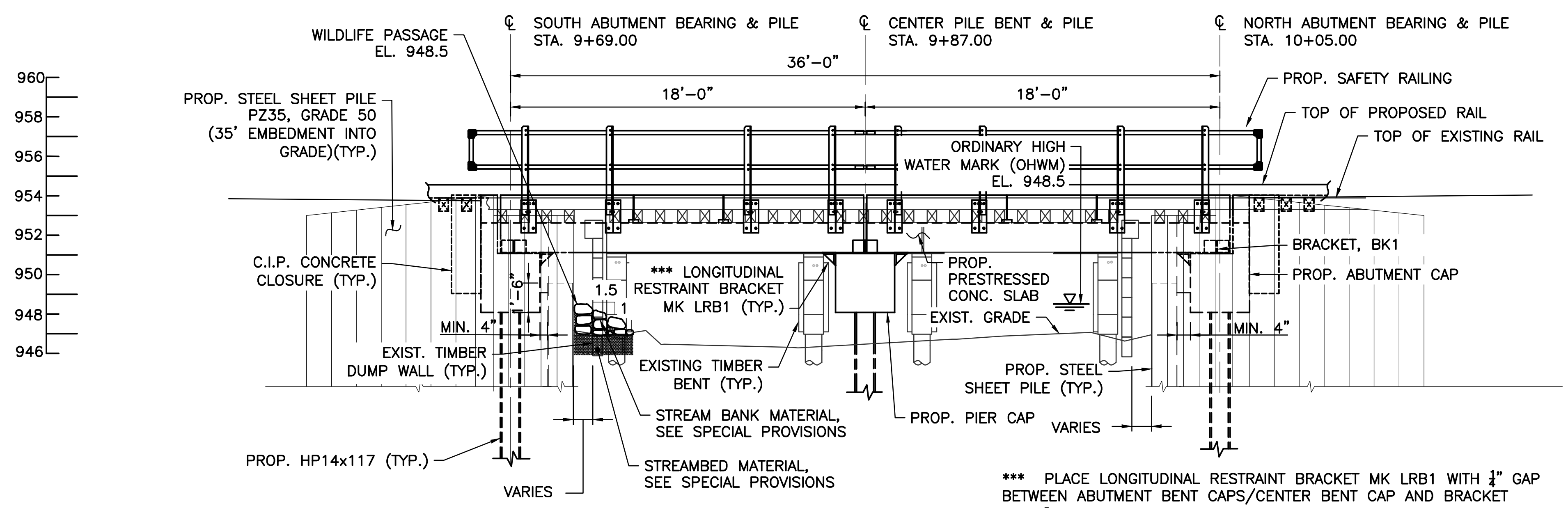
ORIGINAL PLAN DATE: DECEMBER 29, 2020

SHEET 2 OF 4



BRIDGE PLAN

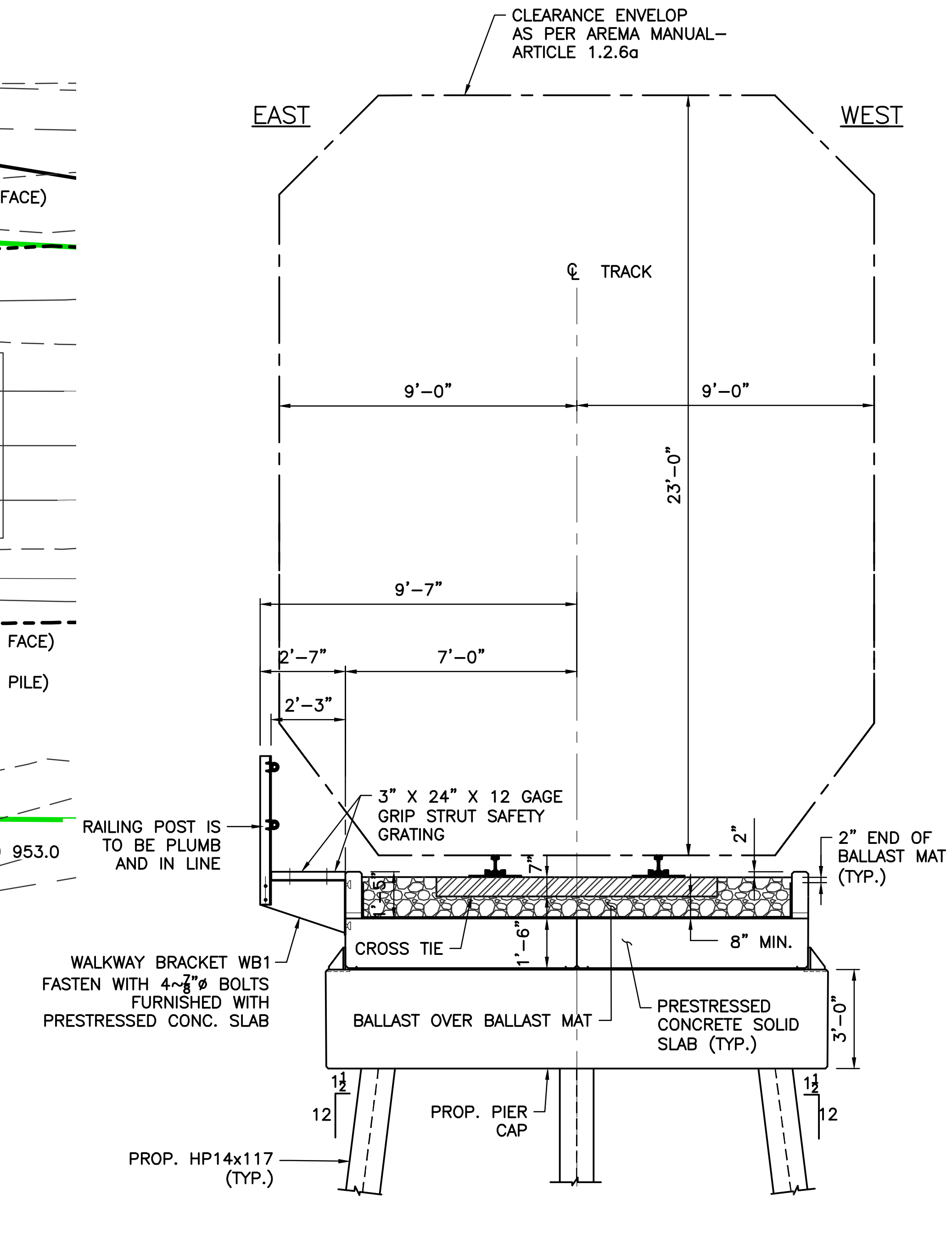
SCALE: ⅛" = 1'-0" @ 11" BY 17"



*** PLACE LONGITUDINAL RESTRAINT BRACKET MK LRB1 WITH ¼" GAP BETWEEN ABUTMENT BENT CAPS/CENTER BENT CAP AND BRACKET AND 5/16" FILLET FIELD WELD TO PLATE IN BOTTOM OF BEAM.

ELEVATION

SCALE: ⅛" = 1'-0" @ 11" BY 17"



SECTION A

SCALE: 3/16" = 1'-0" @ 11" BY 17"

NOTES:

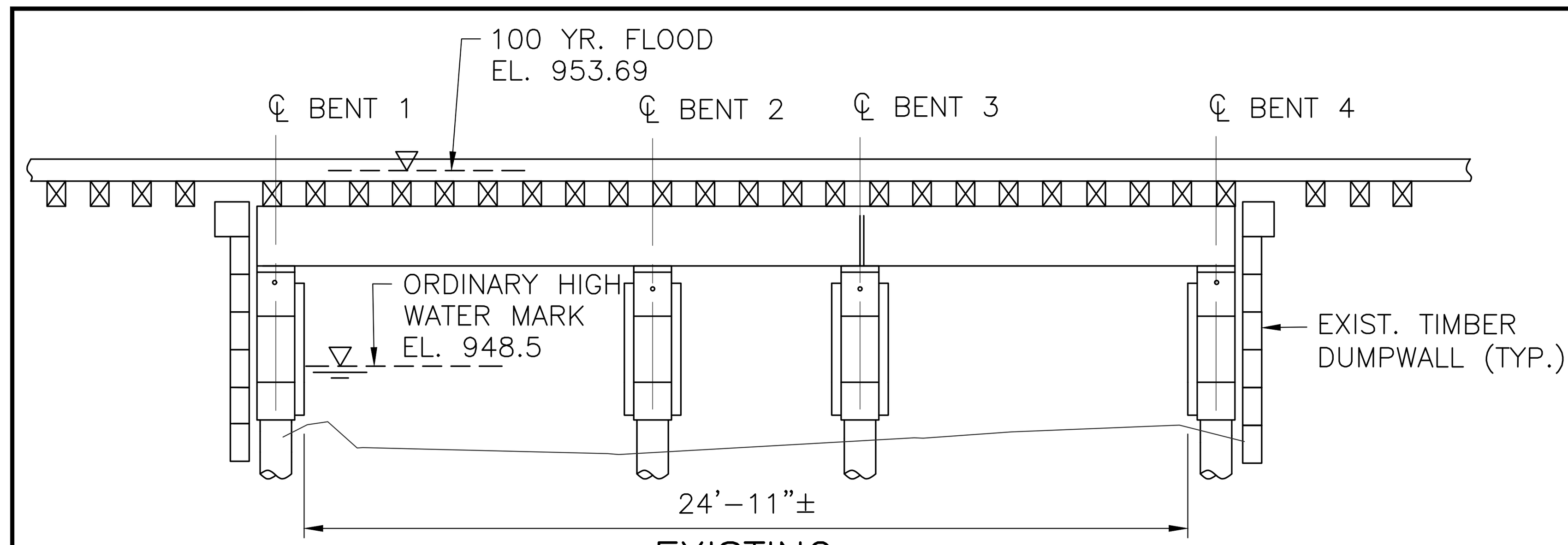
1. FOR GENERAL NOTES, SEE SHEET S-1.
2. W.P ELEVATIONS CORRESPOND TO THE ELEVATION OF THE TOP OF THE RAIL AT STATION INDICATED.
3. FILL GAP BETWEEN END OF BEAM AND FACE OF BACKWALL WITH PLIES OF PREFORMED JOINT FILLER.

ABBREVIATIONS:

W.P. WORKING POINT
TYP. TYPICAL

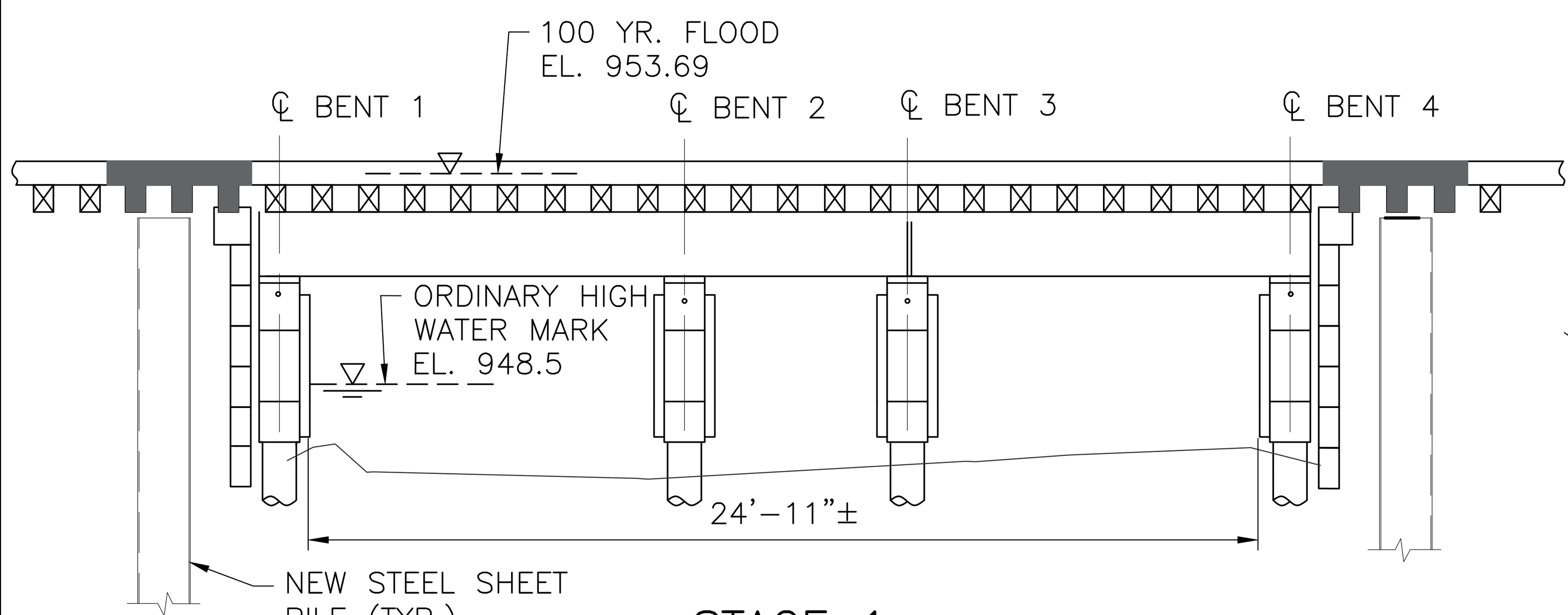
WP#	STATION	NORTHING	EASTING	ELEVATION (TOP OF RAIL)
1	9+69.00	2961803.1298	184857.4770	954.64
2	9+87.00	2961821.0570	184855.8593	954.63
3	10+05.00	2961838.9841	184854.2416	954.60

SECOND REVISION DATE: OCTOBER 25, 2021
FIRST REVISION DATE: FEBRUARY 12, 2021
ORIGINAL PLAN DATE: DECEMBER 29, 2020



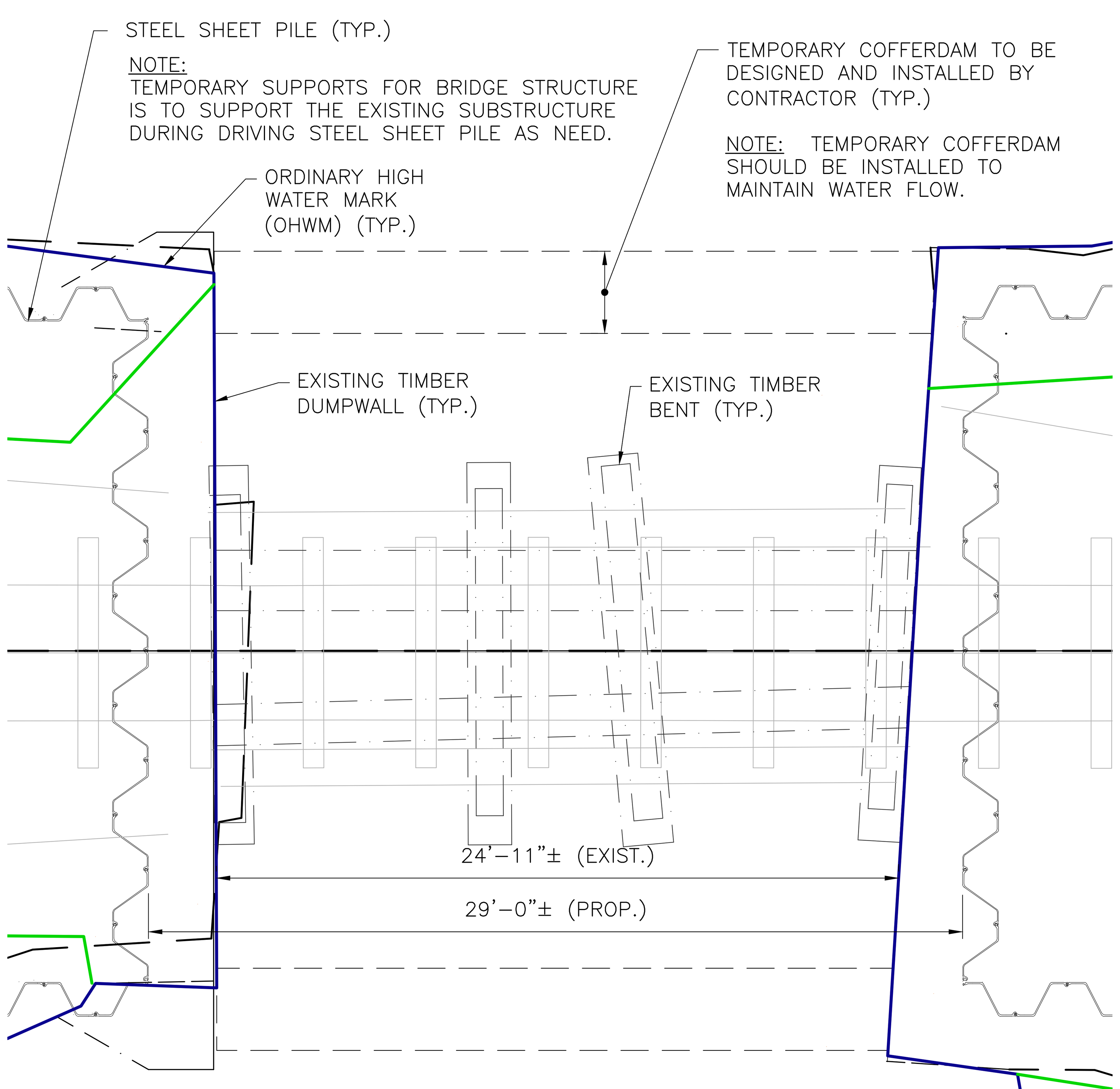
EXISTING

SCALE: 1/8" = 1'-0" @ 11" BY 17"



STAGE 1

SCALE: 1/8" = 1'-0" @ 11" BY 17"



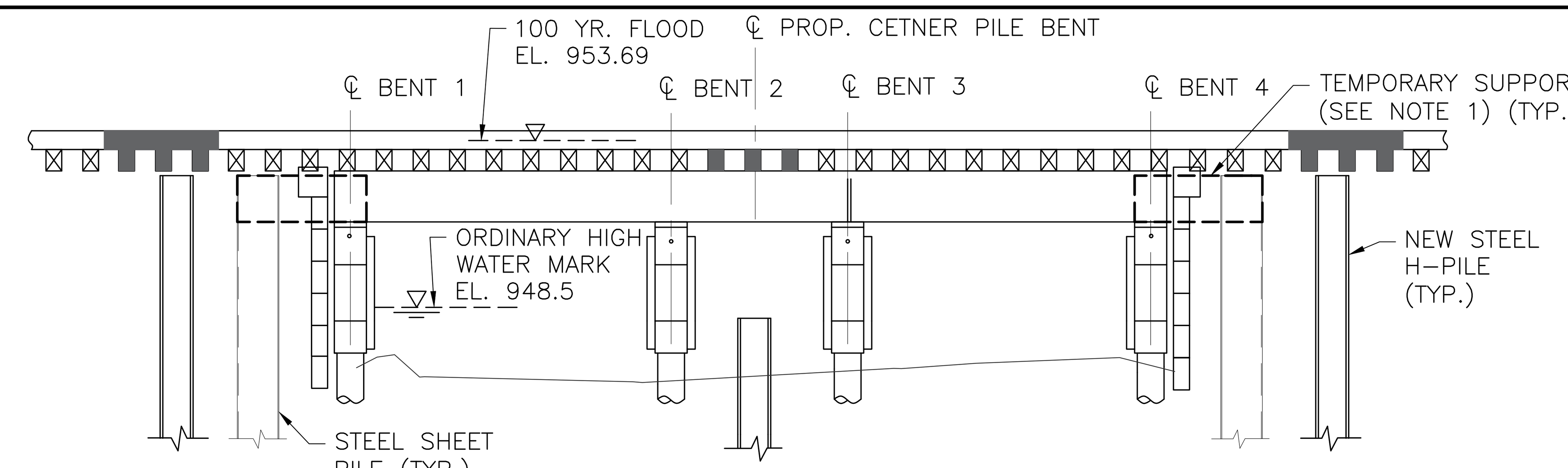
STAGE 2

SCALE: 1/8" = 1'-0" @ 11" BY 17"

LEGEND:

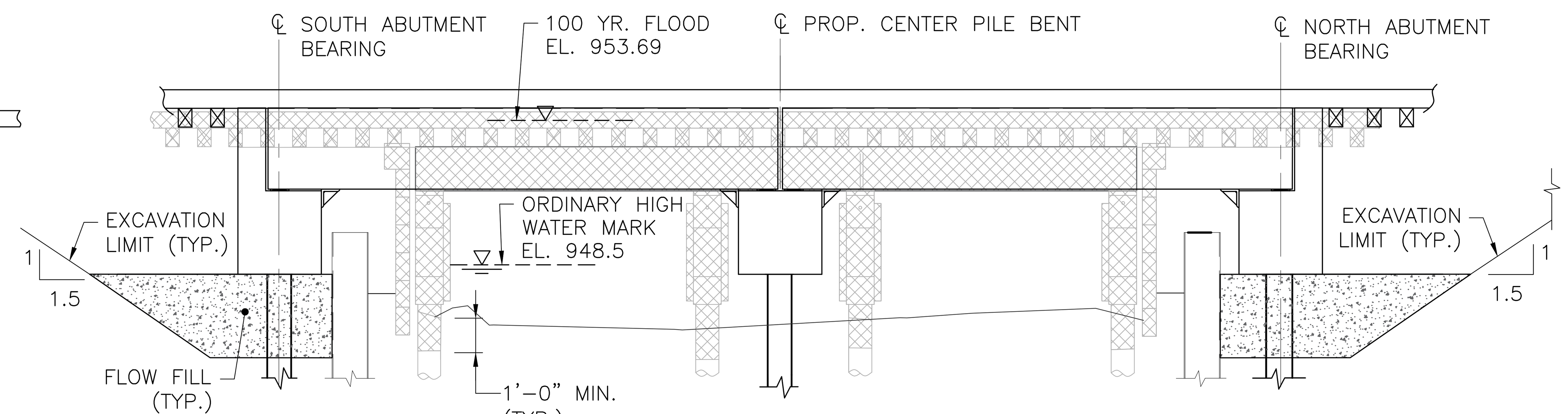
TEMPORARY REMOVAL

EXISTING STRUCTURAL REMOVAL



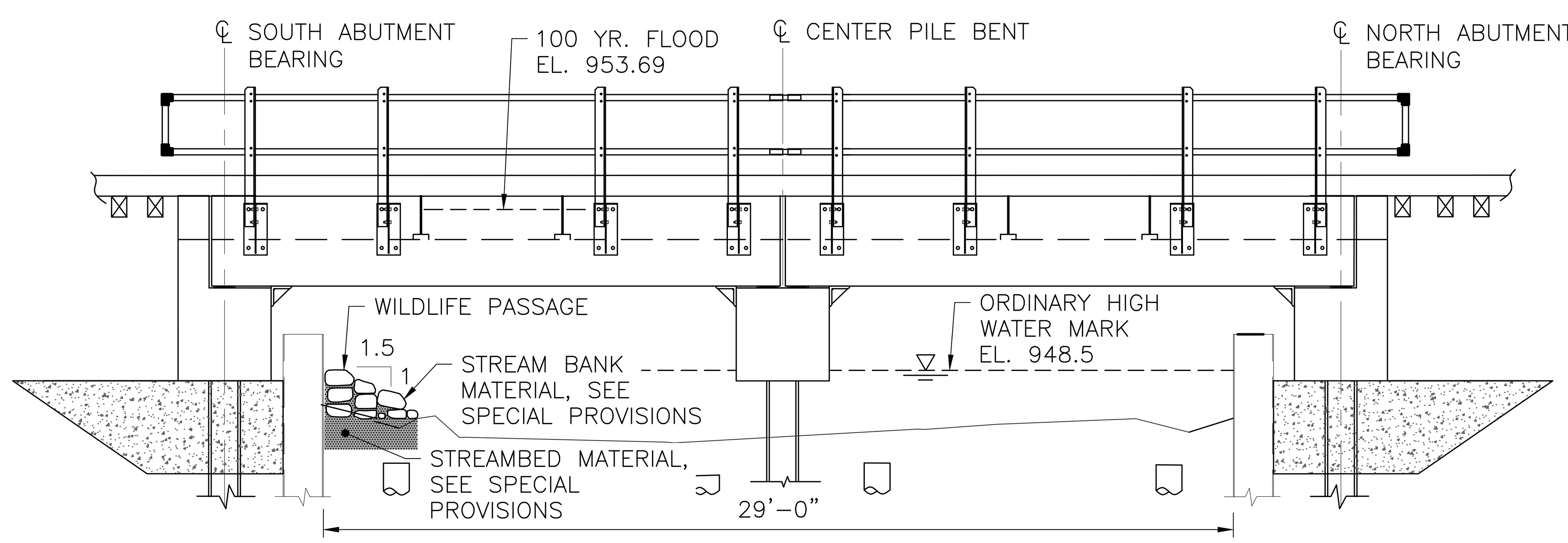
STAGE 3

SCALE: 1/8" = 1'-0" @ 11" BY 17"



STAGE 4

SCALE: 1/8" = 1'-0" @ 11" BY 17"

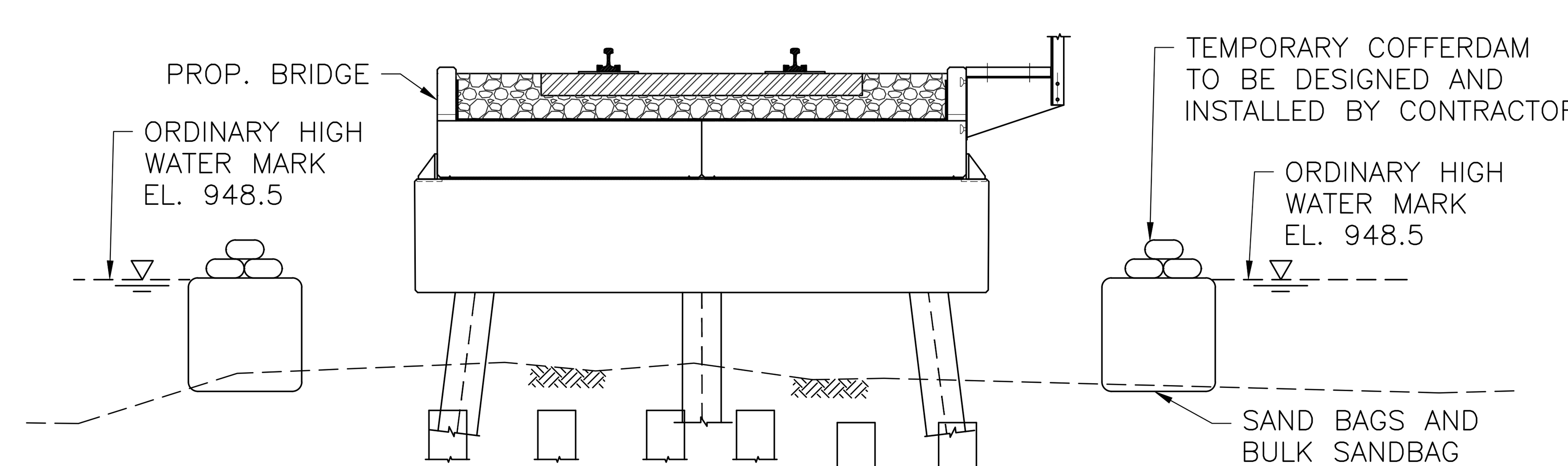


FINAL

SCALE: 1/8" = 1'-0" @ 11" BY 17"

TEMPORARY SUPPORT NOTE:

1. TEMPORARY TRACK SUPPORT BETWEEN END BENT AND PROPOSED SHEET PILE SHALL BE DESIGNED AND FABRICATED BY THE CONTRACTOR PRIOR TO CONSTRUCTION IN CASE EXISTING DUMP WALL DAMAGED DURING INSTALLATION OF SHEET PILES. DESIGN OF TEMPORARY SUPPORTS SHALL BE STAMPED BY A PROFESSIONAL STRUCTURAL ENGINEER REGISTERED IN THE COMMONWEALTH OF MASSACHUSETTS AND SUBMITTED TO THE ENGINEER FOR REVIEW AND APPROVAL BEFORE FABRICATION. COST OF TEMPORARY SUPPORT SHALL BE INCIDENTAL TO STEEL SHEET PILE.



COFFERDAM DETAIL SECTION

SCALE: 1/8" = 1'-0" @ 11" BY 17"

SUGGESTED CONSTRUCTION STAGING:

STAGE 1–STEEL SHEET PILE INSTALLATION

WORKING HOURS SHALL BE DURING NON-TRAIN OPERATION HOURS.

1. REMOVE EXISTING CROSS TIES AND RAIL TEMPORALLY, TO FACILITATE INSTALLATION OF STEEL SHEET PILES.
2. INSTALL NEW STEEL SHEET PILES FOR THE NEW STRUCTURE ONE ABUTMENT LOCATION AT A TIME.
3. RESTORE TIES AND RAIL.

STAGE 2–COFFERDAM INSTALLATION

WORKING HOURS SHALL BE DURING NON-TRAIN OPERATION HOURS.

1. COFFERDAM TO BE DESIGNED AND INSTALLED BY THE CONTRACTOR PRIOR TO THE STEEL PILE INSTALLATION.
2. CONTRACTOR SHALL MAINTAIN THE WORK AREA IN DRY CONDITION DURING CONSTRUCTION.

STAGE 3–H-PILE PRE-INSTALLATION

WORKING HOURS SHALL BE DURING NON-TRAIN OPERATION HOURS.

1. REMOVE EXISTING CROSS TIES AND RAIL TEMPORALLY TO FACILITATE THE INSTALLATION OF H-PILES.
2. INSTALL NEW H-PILES FOR THE NEW STRUCTURE ONE PIER/ABUTMENT LOCATION AT A TIME.
3. RESTORE TIES AND RAIL.

STAGE 4–EXISTING BRIDGE REMOVAL AND INSTALLATION OF BRIDGE

WORKING HOURS SHALL BE DURING A WEEKEND CLOSURE.

1. REMOVAL OF EXISTING SUPERSTRUCTURE INCLUDING EXISTING TIES AND RAILS.
2. REMOVAL OF EXISTING TIMBER BENTS AND DUMPWALLS. TIMBER PILES TO BE CUT AND REMOVED 1 FOOT MIN. BELOW EXISTING GROUND LINE. THE EXISTING TIMBER PILES BELOW GROUND SHALL REMAIN IN PLACE.
3. EXCAVATE EXISTING GROUND FOR THE NEW ABUTMENT.
4. CUT TOP OF NEW STEEL SHEET PILES AND STEEL H-PILES AT NORTH AND SOUTH ABUTMENTS TO SUIT EXCAVATION AND CONSTRUCTION OF ABUTMENTS.
5. INSTALL AND WELD THE NEW PRECAST ABUTMENT AND PIER CAPS TO THE PRE-INSTALLED H-PILES.
6. BACKFILL TO ABUTMENTS SHALL BE PLACED SIMULTANEOUSLY.
7. INSTALL BEARINGS TO THE ABUTMENT AND PIER CAPS.
8. INSTALL NEW SUPERSTRUCTURE.
9. INSTALL TEMPORARY TIMBER CRIBS AND RAILS.
10. OPEN BRIDGE TO TRAIN SERVICE

STAGE 5– RAISE OF TRACK PROFILE AND FINAL BRIDGE INSTALLATION

WORKING HOURS SHALL BE DURING A WEEKEND CLOSURE.

1. REMOVE TEMPORARY TIMBER CRIBS AND RAILS.
2. PERFORM TRACK WORK ON BRIDGE APPROACHES.
3. INSTALL BALLAST MAT, BALLAST, WOOD TIES AND RAILS.
4. INSTALL STEEL WALKWAYS AND HAND RAILINGS.
5. REMOVE COFFERDAM.
6. OPEN TRACK AND BRIDGE TO TRAIN SERVICE.

SECOND REVISION DATE: OCTOBER 25, 2021
FIRST REVISION DATE: FEBRUARY 12, 2021
ORIGINAL PLAN DATE: DECEMBER 29, 2020
SHEET 4 OF 4

MASSDOT MW - 1

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MassDOT MW-1

RECOMMENDED PRACTICE

FOR THE

MAINTENANCE OF TRACK AND SPECIAL TRACKWORK

Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116

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MassDOT MW-1

RECOMMENDED PRACTICE

FOR THE

MAINTENANCE OF TRACK AND SPECIAL TRACKWORK

Document No. ____

Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116

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MassDOT MW-1

RECOMMENDED PRACTICE

FOR THE

MAINTENANCE OF TRACK AND SPECIAL TRACKWORK

Director of Railroad Properties
Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116

Effective July 1, 2018

Chalita Belfield

Chalita Belfield
Director of Railroad Properties

Date: <u>July 1, 2018</u>

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RECOMMENDED PRACTICE

FOR THE

MAINTENANCE OF TRACK AND SPECIAL TRACKWORK

This Manual belongs to:

Name: ____

Employee #: ______________________________________

Address: ____

____

____

Phone:____

If this Manual is found,
please return it to the address below:

Director of Railroad Properties
Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116

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MassDOT MW-1

MANUAL REVISIONS

We welcome your comments on the MassDOT Manual. Please send all suggestions to:

Director of Railroad Properties
Massachusetts Department of Transportation
10 Park Plaza, Suite 4160
Boston, MA 02116

Suggested revisions to this Manual should be submitted in writing in accordance with the following format.

Section/Paragraph Number ______________________________

Page Number ______________________________

Recommended Changes, Corrections, or Questions:

____

____

____

Submitted by:

Name ______________________________

Operating Railroad Company ______________________________

Address ______________________________

____

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Phone ______________________________

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MassDOT MW-1

RECOMMENDED PRACTICE

The Massachusetts Department of Transportation (MassDOT) is committed to providing the safest and most efficient rail service to our customers by maintaining and upgrading the Commonwealth's track infrastructure and assets using best industry recommended practice.

MassDOT has sought to contract with Operating Railroad Companies that will work cooperatively with MassDOT, and that will maintain the Commonwealth's track system at the required standards with competent and dedicated employees.

MassDOT requires their designated Operating Railroad Companies to perform diligent inspections, prepare maintenance and repair programs, and ensure the proper maintenance of track in accordance with the governing operating agreements.

Recommended Practice is based on the best practice developed by and in current use on the United States and Canadian passenger and freight railroads. They allow for a common language amongst railroad administrators, maintenance personnel, contractors, material and equipment suppliers and all others concerned with railroad safety.

Each of the Operating Railroad Companies are currently under agreement with MassDOT. The information found in this Manual contains tables, instructions, and references designed for track and special trackwork as a guide for maintenance personnel in their everyday efforts to maintain a safe and efficient plant.

The MassDOT Manual is a manual of recommended practice. We recognize that best practice of maintenance of way (MOW) continues to change due to the location, environment, operation, and geographic conditions of individual railroads.

The MassDOT Recommended Practice Manual is meant to aid and assist the Operating Railroad Companies to maintain MassDOT-owned tracks in a safe and efficient manner at a reasonable cost. Performing maintenance in accordance with the recommended practice in the MW-1 will meet the expectations of the Commonwealth and provide uniform practice between the different properties of the Operating Railroad Companies.

As of July 2018, the Operating Railroad Companies operate rail freight service and maintain the MassDOT-owned track infrastructure pursuant to License and Operating Agreements with MassDOT on the following line segments:

- Adams Industrial Track: MP 0.0 to MP 5.2
- Conn River Main Line: MP 0.38 to MP 49.7
- Housatonic Railroad: MP 50.0 to MP 85.9
- Massachusetts Central Railroad: MP 1.6 to MP 25.0
- Framingham Secondary: MP 0.0 to MP 21.05
- Middleboro Subdivision:
    - Attleboro Secondary: MP 0.0 to MP 8.6
    - New Bedford Secondary: MP 8.6 to MP 13.3
    - Middleboro Branch: MP 13.3 to MP 21.1
- New Bedford Secondary: MP 13.3 to MP 31.8
- Fall River Secondary: MP 0.0 to MP 12.0
- Cape Main Line:
    - Buzzards Bay Secondary: MP 36.3 to MP 54.7
    - Hyannis Secondary: MP 55.0 to 78.5
- Falmouth Secondary: MP 0.0 to MP 6.8
- South Dennis Secondary: MP 0.0 to MP 2.8
- Dean Street Industrial Track: MP 0.0 to MP 1.5
- Watuppa Branch: MP 6.0 to MP 8.0

MassDOT MW-1

PURPOSE AND USE

The MassDOT MW-1 was developed for MassDOT Rail and Transit Division and selected Operating Railroad Companies who have contracted with MassDOT Rail and Transit Division to operate and maintain lines of track owned by the Commonwealth, as a manual of best practice for the maintenance of track and associated trackwork components. Materials presented in this handbook establish and define MassDOT Rail and Transit Division recommended practice for maintenance of track owned by MassDOT Rail and Transit Division and operated by Operating Railroad Companies under contractual agreements with MassDOT Rail and Transit Division. These practices have been developed to meet the needs of the MassDOT Rail and Transit Division and may be used exactly as presented or modified as is necessary and desirable to meet the present and future needs of the Railroads operating and maintaining MassDOT Rail and Transit Division rail lines, in accordance with the terms of the governing License and Operating Agreements.

In all cases, inspection and restoration of track must be performed in accordance with Federal Railroad Administration (FRA) Part 213, Track Safety Standards.

The intent of the recommended practice is not to establish artificially rigid procedures governing track maintenance but rather to serve as guidelines for prudent track maintenance practice. These guidelines must be used in concert with proper exercise of judgment based upon experience and knowledge of service requirements.

The maintenance limits in the MassDOT MW-1 are unique and are intended to supersede the inspection and restoration limits given in FRA Part 213, provided that the more restrictive practices should be followed. For example, the track gage limits given in the MassDOT MW-1 (53.0(M)) are more restrictive than the track gage limits found in FRA Part 213 (§213.53).

Track maintenance limits and recommended practice in the MassDOT MW-1 are to be used for everyday maintenance activities. The limits act as a trigger to prompt the maintenance or reconstruction of track. The track and related rail infrastructure must be maintained in accordance with the requirements of the relevant License and Operating Agreement between MassDOT Rail and Transit Division and the Operating Railroad

Company. The Commonwealth expects that wherever possible, track shall be maintained so that the track structure does not fall below track maintenance limits established in the MassDOT MW-1.

In all cases, MassDOT Operating Railroad Companies will strive to restore track, make track repairs, and maintain track at or above the respective maintenance limits given in the MassDOT MW-1.

The development of the MassDOT MW-1 involved many hours of input from railroad professionals, and represents the latest recommended practice approved by the MassDOT Director of Railroad Properties. It is understood that these practices are subject to revisions as new technology and improved techniques are established. Other practices may be found to be equally acceptable and, as a result, the materials contained in the MassDOT MW-1 may be modified from time to time to promote the understanding of and efficiency and economy of maintenance of MassDOT-owned rail lines.

The MW-1 is an interactive document. It is expected that every individual that has reason to use this document will constantly strive to offer suggestions and constructive criticism to improve the overall understanding, use, and quality of this Manual.

Modifications to these recommended practice materials must be made in writing, and incorporated into the Manual following approval by MassDOT Rail and Transit Division.

MassDOT MW-1

TABLE OF CONTENTS

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MassDOT MW-1

RECOMMENDED PRACTICE

FOR THE

MAINTENANCE OF TRACK AND SPECIAL TRACKWORK

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SUBPARTS A-E

RECOMMENDED PRACTICE
FOR THE
MAINTENANCE OF TRACK

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RECOMMENDED PRACTICE FOR THE MAINTENANCE OF TRACK SUBPARTS A-E

TABLE OF CONTENTS

Page

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Subpart A - General

§1.0(M) SCOPE

(a) Maintenance is both spot and out-of-face replacement of components of the track structure such as laying new or relay rail or installing ties so as to maintain the infrastructure in a state-of-good repair.

(1) Maintenance limits are to be used as a triggering mechanism that prompts maintenance or reconstruction.

(2) It is MassDOT's policy to have a track structure that stays between new construction and maintenance limits.

(3) As the track structure wears, maintenance should be programmed before the track reaches the MassDOT maintenance limits.

(4) Should these maintenance limits be exceeded, maintenance must be completed prior to reaching the limits found in FRA Part 213.

(5) Whenever possible, track should be repaired or reconstructed to new track tolerances.

(b) This subpart provides practices that will be used for the maintenance of track. It is for the guidance of Operating Railroad Companies that maintain and repair track.

(c) This subpart contains "maintenance limits" that are to be used when maintaining track and are not to be confused with the minimum limits found in FRA Part 213 or with new track tolerances.

§3.0(M) APPLICATION

The MW-1 applies to all operating railroads that have maintenance and compliance responsibility on MassDOT-owned railroad property.

§5.0(M) MAINTENANCE

(a) The responsible personnel in charge of performing the maintenance work for the Operating Railroad Companies shall be qualified to maintain, restore, or renew trackwork in accordance with FRA §213.7(a), (b), (c) and (d).

(b) The person responsible for the work shall coordinate and report all maintenance work on the appropriate form to the Operating Railroad Company and MassDOT Rail and Transit Division.

(c) A record of all maintenance performed and all required inspection reports shall be maintained by the Operating Railroad Company for the duration of their operating contract. Reports to be provided are as follows:

(1) Track Inspection Reports (planned and special)

(2) Switch Inspection Reports (planned and special)

(3) Rail Defect Inspection Reports:

- Detector Car Report (car to be ridden by Operating Railroad Company Official)
- Rail Failure Report

(4) Reports included in CWR procedures section (see Appendix A, "Continuous Welded Rail (CWR) Procedures").

§7.0(M) DESIGNATION OF QUALIFIED PERSONS TO SUPERVISE CERTAIN RENEWALS AND INSPECT TRACK

(a) Each Operating Railroad Company to which this Part applies shall designate qualified persons to supervise restorations and renewals of track under traffic conditions. Each person designated shall have:

  (1) At least:

    (i) 1 year of supervisory experience in railroad track maintenance; or

    (ii) A combination of supervisory experience in track maintenance and training from a course in track maintenance or from a college level educational program related to track maintenance;

  (2) Demonstrated to the owner that he or she:

    (i) Knows and understands the requirements of this Part that apply to the restoration and renewal of the track for which he or she is responsible;

    (ii) Can detect deviations from those requirements; and

    (iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

  (3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements in this Part.

(b) Each Operating Railroad Company to which this Part applies shall designate qualified persons to inspect track for defects. Each person designated shall have:

  (1) At least:

    (i) 1 year of supervisory experience in railroad track maintenance; or

    (ii) A combination of supervisory experience in track maintenance and training from a course in track maintenance or from a college level educational program related to track maintenance;

  (2) Demonstrated to the owner that he or she:

    (i) Knows and understands the requirements of this Part that apply to the inspection of track for which he or she is responsible; and

    (ii) Can detect deviations from those requirements; and

    (iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

  (3) Written authorization from the track owner to prescribe remedial actions to correct or safely compensate for deviations from the requirements in this Part, pending review by a qualified person designated under Paragraph (a) of this section.

(c) Individuals designated under Paragraphs (a) or (b) of this section that inspect continuous welded rail (CWR) track or supervise the installation, adjustment, and maintenance of CWR track in accordance with the written procedures of the track owner shall have:

  (1) Current qualifications under either Paragraphs (a) or (b) of this section;

  (2) Successfully completed a comprehensive training course specifically developed for the application of written CWR procedure issued by the track owner;

  (3) Demonstrated to the Operating Railroad Company that the individual:

    (i) Knows and understands the requirements of those written CWR procedures; and

    (ii) Can detect deviations from those requirements; and

(iii) Can prescribe appropriate remedial action to correct or safely compensate for those deviations; and

(4) Written authorization from the Operating Railroad Company to prescribe remedial actions to correct or safely compensate for deviations from the requirements in those procedures and successfully completed a recorded examination on those procedures as part of the qualified process.

(d) Persons not fully qualified to supervise certain renewals and inspect track as required in Paragraphs (a) through (c) of this section, but with at least one year of maintenance of way (MOW) or signal experience, may pass trains over broken rails and pull-aparts provided that:

(1) The Operating Railroad Company determines the person to be qualified and, as part of doing so, trains, examines, and re-examines the person periodically within two years after each prior examination on the following topics as they relate to the safe passage of trains over broken rails or pull-aparts: rail defect identification, crosstie condition, track surface and alignment, gage restraint, rail end mismatch, joint bars, and maximum distance between rail ends over which trains may be allowed to pass. The sole purpose of the examination is to ascertain the person's ability to effectively apply these requirements and the examination may not be used to disqualify the person from other duties. A minimum of four hours training is required for initial training;

(2) The person deems it safe and train speeds are limited to a maximum of 10 MPH over the broken rail or pull apart;

(3) The person shall watch all movements over the broken rail or pull apart and be prepared to stop the train if necessary; and

(4) Person(s) fully qualified under FRA §213.7 are notified and dispatched to the location promptly for the purpose of authorizing movements and effecting temporary or permanent repairs.

§8.0(M) QUALITY CONTROL

(a) The person in charge of performing the maintenance activity or repair shall be responsible for the overall quality of the work performed.

(b) All maintenance work shall be performed in accordance with this Part.

(c) The Operating Railroad Company shall review the work performed for quality, consistency, and compliance to this Part.

(d) Trackwork repairs that are deficient:

(1) Shall be brought to the attention of the Operating Railroad Company.

(2) May be cause for remedial action.

(e) The Operating Railroad Company shall see that any additional work necessary is performed to bring the repair into compliance with this Part.

(f) The Operating Railroad Company shall be responsible to re-inspect the corrected work to ensure that it is in compliance with this Part.

(g) The Operating Railroad Company is encouraged to make recommendations to the MassDOT Rail and Transit Division as to required modifications to methods, procedures, and practice to improve the overall quality of the work.

§10.0(M) SIDINGS

Maintenance of Way (MOW) forces maintain up to the derail and/or property line on industrial siding tracks.

Subpart B - Roadbed and Right-of-Way

§31.0(M) SEASONAL PREPARATION AND MAINTENANCE

(a) Fall/Winter

(1) Dig out switch (gas, electric) rods

(2) Check heaters

(3) Before winter, clean sand out of flange ways at all highway grade crossings

(4) Keep crossing ends and flanges clear of snow and ice

(5) Ensure adequate supplies of materials/tools and snow equipment

(6) Order frost spikes/shims

(7) Order rope and drift pins from approved supplier and prepare for usage (to heat rail)

(8) Clean snow from switches at switch points, frog points and guard rails

(9) Obtain cleaner and lubricate Sargeant and Greenleaf switch locks

(b) Spring/Summer (Special Inspections after Acts of Nature)

(1) Verify proper neutral temperature of rail installed at less than the desired neutral temperature range and adjust as required (see Appendix A, “Continuous Welded Rail (CWR) Procedures”).

(2) Plan vegetation control.

(3) Remove temporary shims/spikes.

(4) Bring winter equipment back to central headquarters.

(5) Perform heat patrol (kinks).

(6) Perform rain storm patrols – inspection and cleaning of culverts.

(7) Check and cross-cut joints in track.

(8) Lubricate main line hand throw and yard switches.

§33.0(M) DRAINAGE

(a) Drainage is of prime importance for the maintenance of track. Water mixing with materials in the roadbed tends to make the entire track structure unstable.

(b) Water seeping or flowing toward the track should be carried across and off the roadbed or be intercepted and diverted before it reaches the roadbed.

(c) Water falling upon the roadbed should be quickly drained off to side ditches or drainage structures.

(d) Every effort should be made to see that water from adjacent property does not drain on the MassDOT right-of-way. In areas where this condition is observed the MassDOT Rail and Transit Division shall be notified.

(e) Cross drains should be installed and maintained, particularly where bridges, road crossings, and sags interfere with longitudinal drainage.

(f) Maintenance of drainage systems must satisfy the requirements of FRA §213.33.

(g) Distribution of track or construction materials, and the disposal of fouled ballast and ditch materials, should be handled in such a manner that they no longer interfere with track drainage.

(h) Operating Railroad Company shall notify the MassDOT Rail and Transit Division any time debris is dumped on MassDOT property by abutters.

§33.1(M) Culverts

(a) Culverts require regular inspection and maintenance as do other railroad structures. When making inspections of track and roadway, MassDOT' s Operating Railroad Companies should:

(1) Railroad shall have and maintain an updated list of all culvert locations within the right-of-way. Inspectors should be aware of the location of culverts within the right-of-way.

(2) The tie over the culvert should be painted white and web of rail shall be marked with mile post location.

(3) Be aware that culverts must not only support the live load of trains but the dead load of the track structure.

(4) Report the backup of water near culverts or any abnormal conditions around the ends of culverts (e.g., water seeping through ballast structure).

(5) Report any abnormal conditions found in the track structure at a culvert (e.g., loss of ballast). Operating Railroad Company shall then notify the MassDOT Rail and Transit Division.

(6) If unusual conditions are found at culvert locations, take appropriate remedial action. Appropriate remedial action shall be taken by a Operating Railroad Company qualified individual.

(7) For additional information on culverts, see American Railway Engineering and Maintenance Association (AREMA), Chapter I, Part 4, "Culverts."

§35.0(M) CROSS SECTION (ROADWAY)

Wherever possible, roadbeds, embankments, and excavations should be maintained in accordance with the Massachusetts Bay Transportation Authority (MBTA) Book of Standard Plans. Deviation from approved cross sections should not be made without authorization from the MassDOT Rail and Transit Division.

§37.0(M) VEGETATION

(a) Growth of vegetation should be encouraged on slopes of embankments, cuts, and deep ditches to prevent erosion and to maintain stability.

(b) Vegetation growth must be controlled in accordance with the requirements of FRA §213.37.

(c) The goal of MassDOT is to have the right-of-way cleared of both brush and vegetation in the track and to within 25' of the track centerline. This should be accomplished using a combination of brush cutting and weed spraying.

(d) Vegetation on railroad property, which is on or immediately adjacent to roadbed, must be controlled so that it does not:

(1) Become a fire hazard to track-carrying structures;

(2) Obstruct visibility of railroad signs and signals;

(i) Along the right-of-way

(ii) At highway-rail crossings

(3) Interfere with railroad employees performing normal trackside duties;

(4) Prevent proper functioning of signal and communication lines; or

(5) Prevent railroad employees from visually inspecting moving equipment from their normal duty stations.

(e) The Operating Railroad Companies shall develop and carry out vegetation management programs as required by MassDOT.

(f) The Operating Railroad Companies shall provide copies of their approved management programs to the MassDOT Rail and Transit Division.

§39.0(M) SIGNS

(a) Track signs and posts must be placed and maintained in accordance with either the MBTA Book of Standard Plans and/or AREMA Chapter 1, Part 7 Roadway Signs and operating special instructions. They should not be installed so as to interfere with signals or safety appliances.

(b) The following is a list of the common signs, which are maintained by the Operating Railroad's Maintenance of Way Department:

- (1) Whistle Posts (see Paragraph (c) for placement)
- (2) Permanent Speed Restriction Signs (see Operating Railroad Company Time Table Special Instructions) (MBTA Standard Plan No. 3304)
- (3) Temporary Speed Signs (see Appendix D)
- (4) Mile Posts (see appropriate Track Charts) (MBTA Standard Plan No. 3302)
- (5) Station Markers (see Operating Railroad Company Time Table Special Instructions)
- (6) End of Block (see Operating Railroad Company Time Table)
- (7) Stop Boards (see Operating Railroad Company Time Table)
- (8) Clearance Marker (fouling point) painted rail or ties in yellow
- (9) Close Clearance Markers (MBTA Standard Plan No. 3312)
- (10) Yard Limit Signs (see Operating Railroad Company Time Table) (MBTA Standard Plan No. 3304)
- (11) Switch Targets (MBTA Standard Plan No. 3030)
- (12) Spring Switch Markers (SS) (MBTA Standard Plan No. 3304)
- (13) No Trespassing/No Dumping Signs (MBTA Standard Plan No. 3208)
- (14) Cross Bucks (Passive) (MBTA Standard Plan No. 3388)
- (15) Crossing Approach Circuit Signage (XC) at Highway Grade Crossing
- (16) Emergency Notification Sign at all Public and Private Grade Crossings (as per FRA Requirements) (Manual on Uniform Traffic Control Devices (MUTCD) Figure 8B-5)
- (17) Bridge Markers (undergrade and overhead bridges)
- (18) Culvert Markers (mark on web of rail and paint ties white)
- (19) Track Lubricator Signage
- (20) Buried Cable Signs (MBTA Standard Plan No. 3344)
- (21) Low Ground Clearance at Grade Crossings (MUTCD Figure W10-5 and W10-5P)
- (22) Snow Flanger Sign (MBTA Standard Plan No. 3304)
- (23) Will Not Clear Man on Side of Car (MBTA Standard Plan No. 3314)

(c) Whistle post placement:

- (1) Whistle posts are placed 1,320' in advance of a public grade crossing so as to comply with Massachusetts General Law (MGL), Chapter 160 "Railroads," Section 138 "Warning to Public."

§41.0(M) HIGHWAY GRADE CROSSINGS

(a) Typical grade crossing surfaces found on the MassDOT are as follows (see also MBTA Standard Plan Nos. 3100, 3106, 3108, 3120):

  (1) Timber

  (2) Timber and asphalt

  (3) Asphalt with cut flangeways

  (4) Asphalt with rubber rail seal

  (5) Full depth rubber

  (6) Full depth concrete

  (7) Full depth rubber on the gage and rail seal and asphalt on the field side

  (8) Special products as approved by the MassDOT Rail and Transit Division at grade crossings or at pedestrian crossings

§41.1(M) Placement of Devices at Grade Crossings

(a) Whistle signs shall be installed in accordance with Commonwealth of Massachusetts requirements (see §39.0(M)(c)).

(b) The design and placement of grade crossing signage, roadway signage, and appliances at both public and private grade crossings are governed by the Manual on Uniform Traffic Control Devices (MUTCD, see Part 8).

(c) Low ground clearance at grade crossings (see the MUTCD).

§41.2(M) Highway Grade Crossing Maintenance

(a) All roadway signs, highway traffic signal systems, and pavement markings are maintained by the municipality and/or Commonwealth.

(b) The railroad warning devices whether passive or active are maintained by the Operating Railroad Companies.

(c) At private grade crossings, any paving markings or highway signage is the responsibility of the roadway owner. The Emergency Notification Sign is the responsibility of the Operating Railroad Companies.

(d) Crossings should be kept clean and attention given to the following:

  (1) Drainage: sloping the surface, if necessary, and constructing underground drains, as required.

  (2) Surface water flowing along the highway toward the railroad should be diverted before it reaches the tracks.

  (3) The ends of the crossing shall extend at least 2' beyond the width of the highway. Crossing surface installed in a gated pedestrian walkway area should be restricted to the width of the sidewalk gate.

  (4) It is recommended that the ends of the crossing surfaces be protected by either end deflector plate/ballast or asphalt to prevent against dragging equipment.

  (5) Flangeways shall be 2-1/2" wide and not less than 2" deep. They must be kept clean at all times and free of debris, ice, and snow.

  (6) Crossing surface materials and components should be inspected, aligned, and properly secured to the track structure so that the materials cannot damage rolling stock and/or motor vehicles. Crossing surface material that cannot be properly secured and/or repaired shall be removed and temporarily replaced with cold patch or asphalt.

(7) The four quadrant site distances for vehicles approaching the highway grade crossing shall be kept as clear as practicable.

(8) When installing or making general repairs to crossings, track alignment should be established by transit and/or mechanical lining devices.

(9) The condition of crossing approaches is vital to the performance of a grade crossing. Special attention should be paid to the surface and alignment on the crossing approaches so that the ties are tamped and there is a smooth transition into the crossing area.

(10) Special attention should be paid to the maintenance of joints and welds at crossing ends. This includes insulated and conventional track joints, as well as field and plant welds. When performing maintenance, track joints should be eliminated as soon as possible.

(11) Joints must be avoided within the area of the crossing panel.

(12) When working at a crossing, rail should be observed under load to determine if there is excessive rail movement. As track deflects under load, cut spikes tend to loosen. Loose and worn fastening systems should be repaired and/or replaced as necessary to minimize all track and crossing surface movement.

(13) In an emergency (broken weld or rail), when welding joints within the limits of the crossing panel, closure welds may be made by the thermite process.

(14) When changing a broken rail in a crossing, ensure that all clips, spikes, plates, and excessively worn components are replaced and secured. Galvanized clips should be installed. Ties should be tamped. Rails temporarily joined with joint bars should be field welded as soon as practicable. If the broken rail is replaced in CWR territory refer to Appendix A, "Continuous Welded Rail (CWR) Procedures" for proper rail adjustment procedures.

(15) Use of gage rods in crossings is prohibited.

(16) Fastening and clipping devices shall be used that do not interfere with the installation of the crossing surface materials.

(17) Galvanized clips should be used in crossings with an elastic fastening system.

(18) Seasonal clearing of silt and other debris from both crossing approaches.

(19) Clean out flangeways in the Fall (e.g., sand and dirt).

(e) All new crossings must be complaint with the Americans with Disabilities Act (ADA).

(f) MassDOT has a number of different types of highway grade crossings types. Pictures of the more common types are shown below:

(1) Asphalt With Cut Flangeway (not recommended for mainline track except overnight during crossing renewals or for emergency repairs).

(2) Timber and Asphalt

(3) Timber

(4a) Full Depth Rubber with Rail Seal

(4b) Full Depth Rubber with Rail Seal

(5) Full Depth Concrete on Wood or Concrete Ties

(6) Rubber Flangeway and Asphalt

Subpart C - Track Geometry

§53.0(M) GAGE

§53.1(M) Standard for Gage

(a) The standard gage for track, measured between the running rails at right angles to the track, 5/8" below the top of rail, is 56-1/2".

(b) Gage will be 56-1/2" unless specified by the MassDOT Rail and Transit Division.

(c) When gaging is required, care should be taken to not adversely affect the alignment of the track. Changes in prescribed gage should be made in uniform increments as given in §53.2(M).

(d) Gage shall be changed by adjustment of the rail opposite the line rail (preferred method).

(e) In some cases, gage may be adjusted on the line rail only if the adjustment will improve line and ride quality (e.g., joint elbowed out on the line rail).

(f) In cases where the line rail is re-aligned, re-spike line high rail and then re-gage the low rail.

§53.2(M) Maintenance of Gage

(a) Gage shall be measured with a standard track gauge or other authorized devices. These devices must be checked daily prior to use for accuracy.

(b) Maintenance shall be performed when gage reaches the following limits:

Gage Maintenance Limits			
Class of Track	**Minimum (Inches)**	**Maximum (Inches)**	**Maximum Rate of Change in Gage per 31' (Inches)**
1	56-1/8	57-1/2	1
2	56-1/8	57-1/4	3/4
3	56-1/4	57-1/4	3/4
4	56-1/4	57	1/2
5	56-1/4	57	1/2

(c) Gage rods shall be applied only in emergency situations for temporary repair. Permanent repairs to gage should be completed as soon as possible. On main line tracks, gage rods shall only be installed in an emergency and removed as soon as possible.

(d) When using gage rods in signal territory, insulated rods are to be tested by the Signal Maintainer prior to installation. When permanent repairs are completed, gage rods are to be completely removed.

§55.0(M) ALIGNMENT

Alignment is the horizontal location of a railroad as described by curves, spirals, and tangents.

§55.1(M) Maintenance of Alignment

(a) Outer rails of curves and field side rails on tangents should be selected as the line rails. On single tangent track, either rail may be used as the line rail, however, the north or east rail is the preferred line rail. The same line rail shall be used for the full length of the track tangent.

(b) In general, alignment information may be obtained using the following:

(1) The stringline method.

(2) Surveying equipment or a rail-mounted laser.

(3) The automatic geometry system on an approved tamper.

(4) Track geometry car.

(c) Maintenance shall be performed when alignment values reach the limits given in the table below.

(1) Alignment deviation in curves, as defined in this table, is the difference in mid-ordinate value between adjacent stations and not the average of multiple stations (uniformity) as defined in FRA §213.55.

(2) The definition of alignment deviation used in this paragraph, allows the maintainer to achieve alignment tolerances that are more restrictive than those defined in FRA §213.55.

Alignment Maintenance Limits

Class of Track	Tangent Track	Curved Track	
	The deviation of the mid-offset from a 62' chord[(1)] may not be more than (Inches):	The deviation of the mid-ordinate from a 31' chord[(2)] may not be more than (Inches):	The deviation of the mid-ordinate from a 62' chord[(2)] may not be more than (Inches):
1	3-3/4	N/A[(3)]	3-3/4
2	2-1/4	N/A[(3)]	2-1/4
3	1-1/4	7/8	1-1/4
4	1	3/4	1
5	1/2	3/8	1/2

Notes:

(1) The ends of the line shall be at points on the gage side of the line rail, 5/8" below the top of the railhead. Either rail may be used as the line rail; however, the same rail shall be used for the full length of that tangential segment of track.

(2) The ends of the line or chord must be at points on the gage side of the line rail, 5/8" below the top of the rail head. Use line rail in accordance with §55.1(M).

(3) N/A – Not Applicable.

(d) Designation of line rail:

(1) On tangent track in single track either rail or rail on the mile post side.

(2) On tangent track and multiple tracks the field side rail.

(3) In single or multiple tracks in curves on the high/outer rail.

(e) Curve realignment changes in CWR territory must be made in accordance with Appendix A, “Continuous Welded Rail (CWR) Procedures.”

(f) Alignments must be maintained within the prescribed limits given above. Roadway clearances are prescribed in AREMA, Chapter 28 (see Table 28-3-3, “Legal Clearance Requirements by State” (in English Units)).

§55.2(M) Stringlining Curves

(a) Stringlining of curves is a method for determining the most advantageous alignment that can be obtained with reasonable amounts of throw.

(b) Any of the established numerical or mathematical methods, such as the automated geometry system on tampers, the “Bartlett Method” or “Bracket Method,” may be used to calculate the throws of curves.

(c) The practical relationship between station and chord length, mid-ordinate value, and degree of curvature for station lengths most commonly used is shown below:

Degree of Curve	Mid-Ordinate	Station Length	Chord Length
1°	1"	31'	62'
1°	1/4"	15'-6"	31'

(d) In higher degree curves, shorter station lengths and chords are to be used. It may be desirable to use longer station lengths and chords for curves less than 30 minutes.

(e) Basic stringlining principles:

(1) The mid-ordinates of a curve are indicative of its degree of curvature.

(2) The mid-ordinates of a uniform circular curve are equal when measuring offsets using chords of equal length.

(3) The mid-ordinate varies directly with the degree of curvature.

(4) Where track is thrown in or out at any single station on the curve, the mid-ordinate of the curve at the station is affected by the amount of the throw and the mid-ordinates at the adjacent stations are affected by half the throw amount, but in the opposite direction.

(5) All calculations should be checked to ascertain that the calculated throws will actually produce the required changes in mid-ordinates.

§55.2.1(M) Stringline Procedures: Road Worker Protection (RWP) and Personal Protection Equipment (PPE)

(a) Ensure area to be stringlined has the proper RWP Procedures in effect.

(b) A minimum of three people is required when using conventional stringline equipment.

(c) Many curves have grease on the rails with residual amounts on the ties and ballast so caution needs to be taken when walking in areas to be stringlined.

(d) Wear Operating Railroad Company’s designated PPE, to include gloves that protect hands from getting dirty.

(e) Ensure that all stringline equipment is cleaned after use.

§55.2.2(M) Stringline Procedures: Items/Tools Required:

(a) Keel or crayon marker

(b) Writing instrument

(c) Stringline data sheet (as given below) with clip board

(d) 100' cloth tape with 6' folding wood ruler

(e) Stringline paddles with string

(f) Ordinate ruler

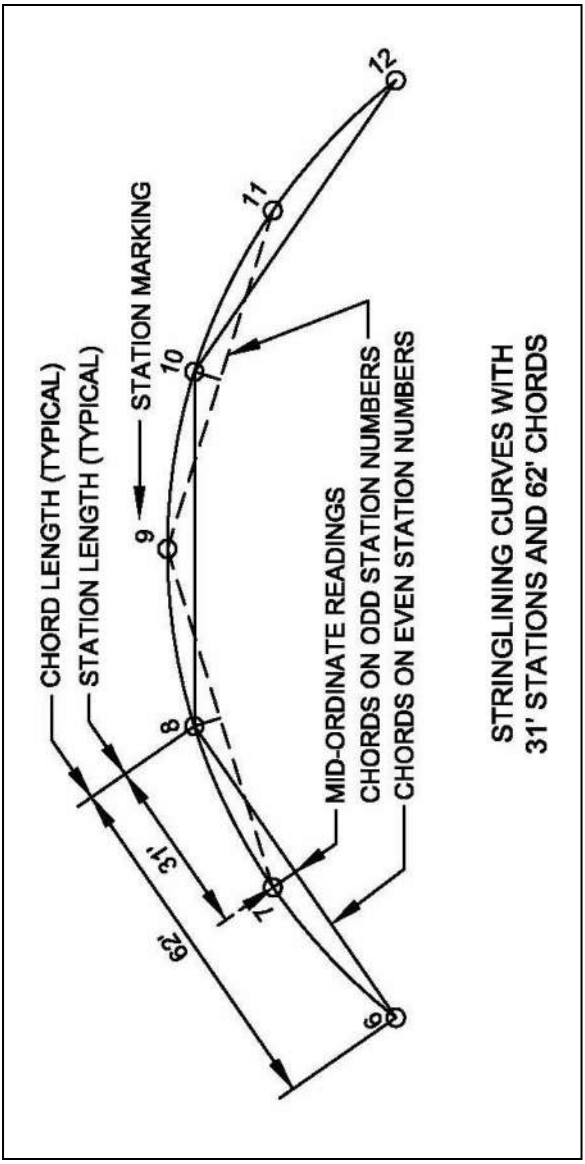
(g) Level board

§55.2.3(M) Stationing Curves and Obtaining Stringline Data

(a) The figure below shows a typical curve with stationing marked out in keel and the chords in place for measurement of mid-ordinates.

(b) Ordinate readings are taken at odd and even stations.

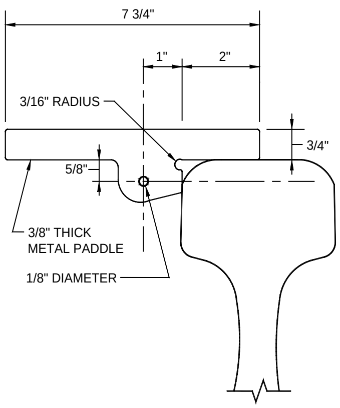
(c) A chord length of 62' is the chord used for this stationing.



Stringlining of Curves

(d) Stationing shall begin at a point on the tangent far enough ahead of the curve to permit the measurement of any reverse curvature or "dog-leg." Stationing shall continue throughout the curve to a point on the tangent five stations beyond the tangent point to permit measurement of any reverse curvature. Mark stations on rail web with keel.

(e) When obtaining mid-ordinate date, stringline paddles should be used to position the string a distance of 1" away from the gage line of the rail, so as to locate and permit measurement of any local deviations in the curve. A typical stringline paddle is shown below.



STRINGLINE PADDLE

SCALE: 3"=1'-0"

Note: In curved track, measurements are taken on the gage side of the high rail (line rail) if possible. If not, field side of low rail may be used.

(f) The Stringline Data Form should be used to record field measurements and for making mathematical calculation (see §55.2.4(M)).

(g) When a conventional ruler is used to measure the mid-ordinate, the actual scale reading should be recorded and a correction made to the mid-ordinate value to compensate for any offset of the stringline from the rail. Conventional stringline paddles require that 1" be subtracted from the readings taken to give the correct mid-ordinate value.

(h) Mid-ordinate measurements should be taken (with an accuracy of 1/16"+/-) with the stringline pulled taut, not affected by the wind, and with the stringline paddles and the scale held horizontal and perpendicular to the gage face of the rail.

(i) Track center lines should be measured and recorded at every station in a two or more track territory. The distance from centerline of track to any obstruction that might interfere with the lining of the curve should be measured and recorded so that limiting throws for these tight spots may be determined.

(j) The apparent location of the curve points Tangent to Spiral (TS), Spiral to Curve (SC), Curve to Spiral (CS) and Spiral to Tangent (ST) should be noted when stationing the curve as appropriate so that the relationship between alignment and required superelevation can be determined.

(k) At all station locations record:

   (1) Crosslevel as read by a level board.

   (2) Gage as read from the 6' ruler (or calibrated level board).

   (3) Track centers if in multiple track territory.

   (4) Physical features in the field such as crossings, turnouts, field or plant welds, joints, curve tags, bridge girders, grease pots, impedance boxes, etc., that may affect the ability to throw a curve.

55.2.4(M) Stringline Data Form

(a) Below is an example of a Stringline Data Form to be filled out when stringlining a curve.

CURVE ID. ___________

MassDOT RAILROAD STRINGLINE DATA FORM

BRANCH __________ **MP**__________ **TRACK** __________ **CHORD (Ft.)** __________ **STATION (Ft.)** __________ **ORDINATE** __________

DEGREE: _________________________ **PRES. ELEV:** _________________________ **PROP. ELEV:** _________________________	**DATE MEASURED:** ___________________________ **DATE LINED:** ____________	**DATE TAGGED:** _______________ **COMPUTED BY:** _______________	**APPROVED BY:** ___________________________________ **DATE:** ___________________________ **STATION 0 AT** _______________ **END**

STA. NO.	TRACK CENTERS	EXIST. GAGE	EXIST. ELEV.	EXIST. ORD.	NOTES	CLEARANCE TO FIXED OBJECT	FINAL ORD.	PROP. ELEV.	THROW	STA.

§57.0(M) CURVES: ELEVATION AND SPEED LIMITATIONS

§57.1(M) General

(a) Elevation, or superelevation, is the vertical distance of the outer rail of a curve above the inner rail. It is provided to overcome or partially overcome the effects of curvature and speed.

(b) Passenger railroads primarily elevate curves to provide adequate ride quality.

(c) Freight railroads primarily elevate curves to provide ride quality and reduce rail wear.

(d) Maximum authorized speed (MAS) for a curve is that specified in the current Operating Railroad Company's Employee Timetable.

§57.2(M) Superelevation

(a) The MassDOT Rail and Transit Division shall establish the amount of superelevation and underbalance to be placed and maintained on each curve.

(b) The superelevation should not exceed values given in Appendix C, "Underbalance Table - Maximum Allowable Operating Speed On Curves."

(c) MAS shall be determined using 3" of unbalance (E_u).

§57.3(M) Superelevation Tags

(a) Curves should be tagged in the field. Points to be marked or tagged on the curves are: TS, SC, CS, and ST.

(b) Information on curve tags shall include the maximum design superelevation and the date the curve is elevated.

(c) Superelevation tags are placed as follows:

(1) The TS and the ST tags are placed 1" off the tie plate and/or elastic fastener perpendicular to the high rail.

(2) The SC and CS tags are placed 1" off the tie plate and/or elastic fastener parallel to the high rail.

§59.0(M) Elevation of Curved Track; Runoff

(a) If a curve or segment of a compound curve is elevated, the full elevation must be provided between points of full curvature throughout the curve, unless physical conditions do not permit. If the elevation does not extend throughout the curve, or segment of a compound curve, the minimum elevation must be used in determining the maximum allowable operating speed under FRA §213.57(b).

(b) Elevation runoff must be at a uniform rate, within the limits of track surface deviation prescribed in FRA §213.63 and it must extend at least the full length of the spiral. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, a maximum of 1" elevation may be run off in tangent track.

Maximum Authorized Speed (MAS)	Maximum Rate of Change in 31'
Up to 59 MPH	1/2"
60 to 90 MPH	3/8"

(3) At least 100' of tangent track, with zero crosslevel, shall be provided between the zero superelevation points in adjacent curves of opposite direction, or facing same hand turnouts, where practicable.

§61.0(M) CLEARANCES AND TRACK CENTERS

§61.1(M) Track Centers

(a) In maintaining alignment, the existing track centers, including equivalent centers on curves, must not be reduced below the minimum established for the territory.

(b) When surfacing track, any changes in track centers must be immediately reported to the Operating Railroad Company and the MassDOT Rail and Transit Division.

(c) In maintaining alignment, existing track center distances, including equivalent distances on curves, should not be decreased without the authority of the MassDOT Rail and Transit Division.

(d) If the measured track center in tangent track is less than 12'-6" notify the MassDOT Rail and Transit Division for guidance.

(e) On curves, the tangent track center must be increased as follows (see MassDOT MBTA Plan 1018):

- (1) Where the amount of superelevation is the same on adjacent tracks or the superelevation of the inner track is greater than the superelevation of the outer track, increase the tangent track center distance at a rate of 2" per degree of curve (CRDS(6)(D)(2)).[1]
- (2) Where the amount of the superelevation of the outer track is greater than the superelevation of the inner track:
  - (i) Increase the tangent track center distance at a rate of 2" per degree of curve and 3-1/2" for each 1" difference in elevation between the outer and inner tracks (and/or tracks under consideration) (CRDS(6)(D)(4)).[1]
- (3) When aligning and super-elevating curves, the required increase in track centers should be as given in Paragraphs (e) (1) and (2) of this Part.
- (4) Track centers that do not meet the requirements of the MBTA Plan 1018 should be reported to the MassDOT Rail and Transit Division.

(f) Standard Tangent Track Center Dimensions:

- (1) The standard track center for tangent main line tracks is 14'-0".
- (2) Track centers of 13'-0" are permissible where 14'-0" centers are not possible as approved by the MassDOT Rail and Transit Division (CRDS (6)(D)(1)).[1]

(g) Track clearance information is given in the MBTA Book of Standard Plans. See:

- (1) Dwg. No. 1012: "Standard Clearances General Roadway Obstructions – Tangent Track"
- (2) Dwg. No. 1013: "Standard Clearances at Stations – Tangent Track"
- (3) Dwg. No. 1014: "Standard Clearances Tangent Track Signal Equipment & Utility Crossings"
- (4) Dwg. No. 1015: "Clearances for New Overhead Bridges"
- (5) Dwg. No. 1017: "Standard Clearances Tangent Track Bridges"
- (6) Dwg. No. 1018: "Standard Track Centers & Side Clearance Increases for Curved Track"
- (7) Dwg. No. 1019: "Clearances at Passenger Platforms"

[1] MBTA Commuter Rail Design Standards Manuals, Vol. I, Revision 1, April 19, 1996.

§61.2(M) Horizontal Clearances

(a) Side Clearance Increase Because of Curvature:

(1) Side clearances must be increased on both the inside and outside of curves. This is to maintain equivalent tangent clearance on curves which is decreased due to:

(i) End overhang of equipment on the outside of curves, and;

(ii) Mid-ordinate swing-in on the inside or curves.

(2) Required side clearances increase on both inside and outside of curves:

(i) 1.5" per degree of curve (AREMA Chapter 28, Section 1.1).

(3) On curved track, side clearances shall be increased 1" per degree of curve. As recommended by AREMA Chapter 28, Section 1.1., Special Notes (1984), clearances to fixed obstructions should be increased within 80' of the curve (from TS and/or ST):

(i) Clearances to fixed objects within 80' of a curve should be increased at least as given in the table below:

Distance from Fixed Obstruction to Curve (TS and/or ST) (Feet)	**Increase in Clearance Per Degree of Curve (Inches)**
20	1-1/2
40	1-1/8
60	3/4
80	3/8

(4) Also see MBTA Standard Plan No. 1018.

(b) Side Clearance Increase Because of Superelevation:

(1) Side clearances on the inside or low side of the curve must be increased to compensate for the inward lean of the equipment when a curve has superelevation.

(2) The increased side clearance amount required to clear an object and/or obstruction is:

(i) Increased side clearances required in inches

$$= h/5 \times E_A,$$

Where:

h = height of obstruction/object in feet above top of rail.

E_A = actual elevation in curve at point in question in inches.

(3) See MBTA Standard Plan No. 1018.

§61.3(M) Vertical Clearances

(a) The minimum preferred vertical clearance required by the Commonwealth of Massachusetts is 22'-6" above top of rail.

(1) See AREMA, Section 3.6, "Legal Clearance Requirements by State."

(2) See Table 28-33, for Massachusetts for both horizontal and vertical clearances.

(b) Compensation for Superelevation:

(1) If tracks are superelevated under an overhead (OH) structure:

(i) Vertical clearance must be increased to accommodate the required vertical clearance out to a point 7'-0" from the centerline of track on a plane parallel to the top of rail of the superelevated track (CRDS (6)(B)(3)).[2]

(2) Relative to the low rail and/or grade rail, the required vertical clearance in superelevated curves is increased by the amount (inches) calculated below:

(i) Increase in Vertical Clearance Required = 143 E_A

Where:

E_A = Superelevation in curve at point of interest

(c) Compensation in Vertical Clearance for Vertical Curves:

(1) When a vertical curve exists under an overhead structure and/or obstruction, additional clearance is required to:

(i) Accommodate the vertical mid-ordinate of railway equipment (cars and locomotives)

(2) For railway equipment up to 90' in length, the required increase in vertical clearance can be calculated as follows (CRDS(6)(B)(4)).[2]

(i) Increase in Vertical Clearance Required = $\dfrac{0.90 \times G_1 - G_2}{8}$

Where:

G_1 = Grade at point on vertical curve (PVC) in percent

G_2 = Grade at point on vertical tangent (PVT) in percent

§61.4(M) Clearance Limiting Objects

(a) For clearance limiting objects, see AREMA, Chapter 28, Table 28-3-3 “Legal Clearance Requirements by State” and the MBTA Book of Standard Plans.

(b) The clearance from the center line of track to objects within the right-of-way such as: signal appliances, signal bridge foundations, bridge abutments and platforms shall not be reduced without ascertaining that the final clearance to the object is no less than given in AREMA, Chapter 28, Table 28-3-3, “Legal Clearance Requirements by State” and the MBTA Book of Standard Plans.

§62.0(M) GRADES

§62.1(M) Grade Limitations

(a) The maximum design gradient shall be 1-1/2% and may be exceeded only with the approval of the MassDOT Rail and Transit Division.

(b) Storage and/or yard track grades shall be level where existing grades and obstructions permit.

(c) When reconstructing track, the existing profile must be retained except where it is possible to reduce the severity, length or the number of grades.

(d) Frequent changes in gradient shall be avoided as this introduces more vertical curves into the geometry and may degrade ride quality and increase train resistance.

(e) The preferred minimum length of vertical tangent is 300'**.**

(f) However, an absolute minimum length of 100' is required (unless approved by the MassDOT Rail and Transit Division).

[2] MBTA Commuter Rail Design Standards Manuals, Vol. I, Revision 1, April 19, 1996.

§62.3(M) Horizontal Curves/Minimum Tangent Lengths

(a) For spiraled compound or reverse curves, the above minimum tangent length between spirals and/or curves is as follows:

(1) A minimum tangent length of 100' on main tracks.

(2) A minimum tangent length of 85' on secondary tracks.

(3) An absolute minimum tangent length of 65', if approved by the MassDOT Rail and Transit Division.

§63.0(M) TRACK SURFACE

§63.1(M) General

(a) Track surface is the relationship of opposite rails to each other in profile and crosslevel.

(b) Track profile is the running surface along the top of the grade rail.

(c) Crosslevel is the difference in elevation across opposite rail heads measured at right angles to the track alignment.

(d) The ideal surface is a uniform profile consisting of constant grades connected by vertical curves, with zero crosslevel on tangents and predetermined crosslevel on curves.

(e) The profile of track being surfaced should not be raised above established grades, except as approved by the MassDOT Rail and Transit Division, who will give consideration to the required elevations and clearances:

(1) In tunnels; and

(2) Under overhead bridges/structures; and

(3) At interlocking plants; and

(4) Highway grade crossings.

(f) Any encroachment upon the published minimum overhead or side clearances from a track will not be permitted.

(1) See AREMA, Chapter 28, Table 28-3-3, “Legal Clearance Requirements by State.”

§63.2(M) Maintenance of Track Surface

(a) The following criteria will serve as a practical guide for maintaining smooth riding conditions on existing tracks.

(b) The basic tools for determining correct track surface are the standard track level and stringline. The track level should be checked by the employee inspecting the track prior to use. If found to be incorrect, it must be accurately adjusted or replaced. Other approved devices may be used for determining crosslevel, but their accuracy should be determined by comparison with a standard track level in correct adjustment.

(c) When surfacing or raising track, one rail, which shall be the low rail on curves and usually the line rail on tangents, shall be selected as the grade rail. The other rail must be brought to surface by adjusting the crosslevel as required.

(d) For Track Classes 1-5 track, surface may not deviate more than the amount prescribed in the following table.

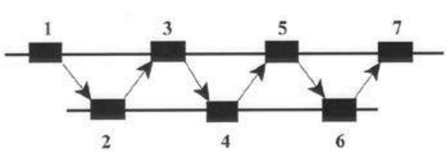
Surface Maintenance Limits

Track Surface	Class of Track				
	1	**2**	**3**	**4**	**5**
The runoff in any 31' of rail at the end of a raise may not be more than (inches):	2-5/8	2-1/4	1-1/2	1-1/8	3/4
The deviation from uniform profile on either rail at the mid-ordinate of a 62' chord may not be more than (inches):	2-1/4	2	1-5/8	1-1/2	1
The deviation from zero crosslevel at any point on a tangent or the reverse elevation on curves may not be more than (inches):	2-1/4	1-1/2	1-1/4	1	3/4
The difference in crosslevel between any two points less than 62' apart may not be more than (inches):*(1, 2)	2-1/4	1-1/2	1-1/4	1	3/4
*Where determined by engineering decision prior to June 22, 1998 due to physical restrictions on spiral length and operating practices and experience, the variation in crosslevel on spirals per 31' may not be more than (inches):	2	1-3/4	1-1/4	1	

Notes:

(1) Except as limited by Part I, FRA §213.57(a), where the elevation at any point in a curve equals or exceeds 6", the difference in crosslevel within 62' between that point and a point with greater elevation may not be more than 1-1/2".

(2) However, to control harmonics on Track Classes 2-5 jointed track with staggered joints, the crosslevel differences shall not exceed 1-1/4" in all of six consecutive pairs of joints, as created by seven low joints (see diagram below). Track with joints staggered less than 10' shall not be considered as having staggered joints. Joints within the seven low joints outside of the regular joint spacing shall not be considered as joints for purposes of this footnote.



§63.3(M) Surfacing Areas That Require Special Attention

(a) Special attention must be given to the surface and line of track at the ends and approaches of bridges, crossings, and platforms.

(b) When surfacing, installing or tamping ties, particularly in interlocking plants, care must be taken to avoid breaking or damaging bond wires, pipes, cables or wire connections to the tracks. The Signal Maintainer must be notified prior to any work and all signal appliances are to be marked with high-visibility paint. Notify the Signal Maintainer immediately if damage occurs. Care shall be exercised to avoid the dropping or laying of metal tools or objects across the rails and causing a shunt of the signal circuits.

(c) In hot weather when surfacing track, the requirements of FRA §213.119 and Appendix A, “Continuous Welded Rail (CWR) Procedures” must be followed.

(d) During freezing and thawing weather, attention must be given to the surface of track likely to be affected by heaving due to frost action. Surface irregularities due to frost action that cannot be corrected by usual procedures may be temporarily corrected by use of track shims or by de-icing the ballast. Shimming must be performed in compliance with FRA Part 213 and §129.0(M).

(e) Undercutting, out-of-face track surfacing, and out-of-face tie renewal shall be performed in accordance with Appendix A, “Continuous Welded Rail (CWR) Procedures.”

§63.4(M) Surfacing Track

(a) When track is given a general raise, both rails should be raised at the same time. When track jacks are used, they should be placed opposite each other on the field side of the rail and must not be placed between the rails, except when absolutely necessary.

(b) Surfacing track with automated tamping equipment causes ballast breakdown and, therefore, should only be performed where it is determined to be an effective solution to correct track geometry defects or to raise the track to a required profile. Surfacing work shall be executed in a manner that assures maximum durability of the track raise and the ballast materials.

(c) When track is given a general raise, it is important to consider the relationship between the amount of lift and durability of results. In general, average lifts between 1" to 2" are desirable. Higher raises may be performed, with multiple passes, under the authority of the MassDOT Rail and Transit Division.

(d) Adequate ballast for dressing to the required ballast cross section should be distributed in advance of surfacing and aligning track.

(e) CWR track that has been surfaced and aligned and is being returned to service will be inspected by a qualified person before releasing and in accordance with Appendix A, “Continuous Welded Rail (CWR) Procedures.”

(f) Track should not be raised in interlockings or in signal territory until advance notice has been given to the Signal Maintainer so that switches, or other appliances, can be protected and then re-inspected when the work is completed.

Subpart D - Track Structure and Materials

§100.0(M) MATERIALS

"Track structure" materials include: sub-ballast, ballast, ties, rails, rail fastenings, and other track materials (OTM).

§100.1(M) Handling and Care of Materials

(a) Moving materials from place to place and caring for materials on hand is costly and requires careful planning. Therefore, the amount of material on hand and the number of handlings should be kept to a minimum.

(b) Threaded and/or insulated materials and parts should be kept under cover and protected from the weather.

(c) Materials should be distributed in such a manner so as not to become a tripping hazard or be lost prior to installation in track.

(d) Whenever possible, CWR distributed for installation should be distributed clear of the track.

  (1) When necessary to be placed in the center line of the track, the rail ends should be protected by bending them towards the center line of track (proper nosing).

  (2) When unloaded, CWR should be secured and insulated in such a manner as to prevent shunting of the signal system.

  (3) The top of the CWR, when distributed in the center line of track, should not exceed the height of the running rails.

§100.2(M) Classification of Materials

(a) Materials are classified as follows:

  (1) New: Unused, as manufactured.

  (2) Rehabilitated: Worn materials removed from track and repaired to a relay condition for reuse (e.g., rebuilt frogs).

  (3) Relay: Usable (second-hand) material removed from track to be reused with no required work to be performed before re-installation into track, such as:

   - relay ties,
   - relay rail,
   - relay frogs,
   - relay joints,
   - relay fasteners,
   - relay turnouts, and
   - other special trackwork.

  (4) Scrap: Materials removed from tracks that are not suitable for reuse.

§100.3(M) Removal and Disposition of Materials

(a) Materials removed from track shall be classified as relay or scrap (see §100.2(M)).

(b) Relay materials shall be sorted and stored properly and safely at the Operating Railroad Company's designated MOW materials area for reuse.

(c) Scrap materials shall be disposed of by the Operating Railroad Company in accordance with MassDOT, local, State, and Federal regulations.

(d) Reroller materials are used to fabricate other steel products (see §113.4.1(M)).

(e) Materials shall be removed from the work area as quickly as practicable so as to provide for a clean, safe, right-of-way, and stored securely.

§103.0(M) BALLAST; GENERAL

§103.1(M) Ballast Characteristics

(a) Unless supported by a structure, all track must be supported on a material that will:

(1) Transmit and distribute the load of the track and railroad rolling equipment to the sub-ballast and then to sub-grade.

(2) Provide lateral, longitudinal, and vertical restraint for the track.

(3) Provide drainage for the track structure.

(4) Facilitate the maintenance of track elevation, crosslevel, surface, and alignment.

(b) Ballast shall conform to the AREMA recommended practice Chapter 1 and Part 2, Section 2.4 to include Tables 2-1 and 2-2. Ballast may be obtained only from MassDOT Rail and Transit Division approved quarries.

(c) When ballast received is of inferior quality, has improper grading, or contains quantities of screenings, dirt, or foreign matter, it shall be rejected and shall be reported to the Track Supervisor, so that corrective action may be taken.

§103.2(M) Ballast Unloading

(a) To the extent practicable, ballast should be unloaded in position for use with a minimum of rehandling and dressing.

(b) Ballast must be distributed and immediately dressed so that adequate clearance below top of rail is provided for the movement of rolling stock and track equipment. Switches are not to be fouled and guard rails are not to be obstructed.

(c) When unloading ballast cars, caution should be used to ensure that both sides of the car are unloaded equally to maintain the stability of the car while unloading.

(d) Use the table given below to determine typical ballast quantities for track panels and special trackwork renewals.

Renewal Type	Number of Ballast Cars
Track Panels (3 each)	1
Crossing Frogs	1
No. 7, 8, 9, 10 Turnouts	2
No. 15 Turnouts	3
No. 20 and 24 Turnouts	4

§103.3(M) Ballast Section

(a) Ballast and sub-ballast cross sections should conform to AREMA, Chapter 1, Section 2.1, “Design,” Figures 1-2-1 through 1-2-4.

(b) Minimum ballast shoulder widths are:

Jointed Rail 12" shoulder	2:1 slope
CWR Rail 12" shoulder	2:1 slope
CWR on curves 16" shoulder	2:1 slope

(c) On CWR track, take remedial action where there is insufficient ballast (see Appendix A, “Continuous Welded Rail Procedures”).

§103.4(M) Fouled Ballast

(a) Ballast may consist of crushed slag, crushed stone, screened gravel, pit-run gravel, chat, cinders, scoria, pumice, sand, mine waste, or other native material, and is an integral part of the track structure.

(b) Ballast, regardless of the material, must satisfy all four of the requirements stated in the FRA Track Safety Standards.

(c) The sole appearance of fouled ballast (ballast contaminated with broken down ballast particles, mud, coal dust, or any foreign particles), does not warrant a defect or violation to be written, if the ballast section is properly transmitting the load, restraining the track, providing adequate drainage, and maintaining proper geometry.

(d) However, fouled ballast that is unable to provide adequate drainage is of particular concern because it compromises the ability of ballast to meet its other three functions (i.e., to distribute load, restrain track, and maintain proper geometry).

(e) When fouled ballast with inadequate drainage is present, wheel loads are likely to be concentrated, rather than distributed, causing deterioration of components and instability in the area of the defective ballast.

(f) This deterioration of components and instability increases the risk of track shift (such as a track buckle), and also increases the rate of degradation of geometry, and may result in a derailment.

(g) Factors that affect the rate of degradation of components and geometry include the tonnage, traffic density, and operating speeds, as higher tonnage, traffic density, and operating speeds increase the amount and/or frequency the forces exerted on the components

(h) Operating Railroad MOW personnel should look for indicators that the ballast is not performing its four functions, such as the existence of a crosstie and/or geometry condition.

   (1) The term “geometry condition” used here means a track surface, gage, or alignment irregularity that does not exceed the allowable threshold for the designated track class in the Track Safety Standards.

   (2) Operating Railroad MOW personnel are encouraged to use their technical knowledge and professional experience in recognizing fouled ballast, and should take into account the severity of a geometry condition along with the following factors when considering the action and/or remedial action required:

   - Track class and operating speed
   - Traffic density and wheel loads
   - Adequacy of shoulder ballast and crib ballast
   - Track type: route for passenger and/or hazardous materials
   - Potential that the track may deteriorate very rapidly following heavy rains
   - Center-bound cross ties, if observable
   - Rail and fastener conditions
   - Sub-grade condition, if observable
   - Surrounding track structure (embankment or cut, obvious/observable variation of track stiffness of the left from right side of the track, and from the adjacent areas along the track)

- Proximity of the defective ballast locations to switches (special work), joints, bridges, or grade crossings
- Existence of standing water or indications that water had been standing (as water sometimes get trapped beneath the ties and may not be visible on the surface)

§103.5(M) Ballast Cleaning

(a) When ballast in track becomes fouled, it should be mechanically cleaned, or removed, and then replaced to restore performance and proper drainage.

(b) The type of cleaning procedure employed should depend on the nature and extent of the fouling.

(c) Types of ballast cleaning and/or removal activities are described below:

(1) Shoulder ballast cleaning promotes lateral drainage of the track structure. A proper cycle of shoulder cleaning can aid in extending the cycle between undercutting operations.

(2) Undercutting cleans the ballast under the track to include the ties, cribs, and shoulders.

(3) A portion of the ballast removed may be returned to the track for reuse if approved by the MassDOT Rail and Transit Division.

(4) See Appendix A, “Continuous Welded Rail (CWR) Procedures,” for the proper procedures for shoulder cleaning and undercutting of track with CWR.

§103.6(M) Ballast Gradation

(a) The nominal size of crushed stone used for ballast in maintenance and new construction shall be as follows (unless otherwise directed by the MassDOT Rail and Transit Division):

All tracks:

Ballast Size AREMA No. 4 3-4" to 1-1/2"

§109.0(M) CROSSTIES

(a) Crossties shall be made of a material for which rail can be securely fastened. A crosstie must have effective rail fasteners on both the gage and field side of both rails to be considered an effective tie.

(b) Each 39’ segment shall have:

(1) A sufficient number of cross ties which in combination provide effective support that will:

(i) Hold gage within limits prescribed in FRA §213.53(b);

(ii) Maintain service within the surface limits prescribed in FRA §213.63; and

(iii) Maintain alignment within the limits prescribed in FRA §213.55.

(2) The minimum number and type of crossties specified in this section must be effectively distributed to support the entire segment; and

(3) At least one non-defective crosstie of the type specified in this section that is located at a joint.

(4) The minimum number of effective crossties as listed in the table below:

Minimum Number of Effective Crossties			Maximum Distance Between Effective Ties (Center to Center) (Inches)	Maximum Number of Successive Defective Ties (Normal Spacing)
Class of Track	Tangent Track and Curves ≤ 2°	Turnouts and Curve Track > 2°		
1	5	6	100	3
2	8	9	74	2
3	8	10	74	2
4 and 5	12	14	50	1

§109.1(M) Dimensions of Crossties

(a) Wood crossties are 7" in depth, 9" in width and 8'-6" in length (unless otherwise authorized by the MassDOT Rail and Transit Division).

(b) Timber crossties shall be of the following sizes:

Type of Track	Size
Main Line Track	7" grade (7"x9" x 8'-6")
Other Than Main Track and Yard Tracks	6" grade (6"x8" x 8'x6")
Grade Crossings	7" x 9" x 9', 7" x 9" x 10'(1)
Note: (1) Or as recommended by manufacturer.	

(c) The specifications for wood crossties shall be in accordance with AREMA, Chapter 2.

(d) Wooden transition ties may be used at open deck bridge approaches. Transition tie layout is to be approved by the MassDOT Rail and Transit Division.

(e) Concrete and steel ties may be used with the approval of MassDOT Rail and Transit Division.

(1) Concrete ties shall be sized according to MBTA Standard Plan 1120.

§109.2(M) Use of Crossties

(a) The use of crossties, other than those described in §109.1(M), shall be approved by the MassDOT Rail and Transit Division.

(b) The type and spacing of ties for each line and class of track shall be designated by MassDOT.

(c) The number of ties and tie spacing for each line and class of track shall be designated by the MassDOT Rail and Transit Division in accordance with the service requirements. Center to center tie spacings are given in the table below:

Type of Track	Distance (Inches)
Main Tracks	19-1/2"
Within Grade Crossing[(1)]	18"
Other Tracks	22"
Concrete Ties	24"
Steel Ties[(1)]	20"-24"
Note: [(1)] Or as recommended by the manufacturer.	

(d) It is recognized that ties will not normally be re-spaced except during reconstruction.

(e) However, when ties are installed out-of-face, ties should be re-spaced wherever practicable.

§109.3(M) Placement of Crossties

(a) Wood Crossties

(1) Ties should be placed in track with the wider heart wood face down and square to the line of the rail.

(2) The ends of standard 8'-6" ties should be brought to a uniform line 18" from the edge of the base of rail on the line side as follows:

(i) On single tangent track, line the ties to the mile post side of the track.

(ii) On roads with two or more main tracks, line the field ends of ties.

(iii) On all curved track, ties shall be lined to the high rail.

(iv) When necessary to install non-standard length ties, they shall be centered in the track.

(b) Any Crossties

(1) Ties shall be kept sufficiently spaced and square to the line of rail to permit proper tamping and distribution of load.

(2) When necessary, ties should be re-set to standard spacing.

(3) Ties shall be square to the line of rail so that fastening systems are not subjected to a torsional load because of tie skewing.

(4) When installed, crossties shall be properly tamped 12" on both sides of the base of rail.

§109.4(M) Preventing Crosstie Damage

(a) General:

(1) When handling or spacing ties, care shall be taken not to damage them with MOW equipment, picks, and spiking hammers.

(2) Tie tongs, lining bars and other suitable tools or tie spacing equipment shall be used, so as to prevent tie damage.

(3) For additional information on fastener application see §127.0(M).

(b) Wood Crossties:

(1) Adze ties as required to obtain a sound and true bearing to support the tie plate.

(2) If a tie will be reused, cedar tie plugs or an approved hole filler must be used to fill holes where spikes, pins and lag screws have been removed. The tie shall be installed with hole side up.

(3) Square tie plugs (5/8") are used with spikes and pins, round tie plugs (3/4" diameter) are used with lag screws.

§110.0(M) Switch Timber

(a) Timber switch ties shall be 7" grade (7" x 9"), except for power switch machine timbers, which shall be a cross section of 9" x 10", with lengths as shown on the standards plans.

(b) Use of switch timbers of other material must be approved by the MassDOT Rail and Transit Division.

§111.0(M) Bridge Timber

(a) Oak or Southern Yellow Pine Timber, or approved equal by the MassDOT Rail and Transit Division, shall be used on all open deck bridges.

(b) Bridge ties shall be adzed, framed, and sized according to framing plans prior to treatment. Suitable holes must be bored for drive spikes that fasten tie spacing bars on timbers.

(c) Where ties are bored or adzed in the field, they shall be treated with an appropriate preservative.

(d) Bridge ties shall be fastened to the structure with galvanized hook bolts as follows:

- On tangent track every 4^{th} tie shall have two hook bolts to connect the tie to the deck, or
- On curved track every 3^{rd} tie shall have two hook bolts to connect the tie to the deck; or
- The MassDOT Rail and Transit Division shall specify how many ties shall have hook bolts that connect ties to the deck on any and all spans.

(e) Lag screws shall be used in holes bored to size to fasten galvanized tie spacing bars on timber (see MBTA “Standard Book of Plans”).

(f) Tie spacing bar, spacer block, and hook bolt details are given on MBTA Standard Plan No. 1236 “Bridge Timber Anchoring Detail.”

(g) All open deck bridges shall have spacer blocks between all timber (see MBTA “Standard Book of Plans”).

§113.0(M) RAIL

§113.1(M) Branding and Stamping

(a) Branding shall be rolled in raised characters on the side of the web of each rail at a minimum of every 16' in accordance with the following requirements:

(1) The data and order of arrangement of the branding shall be as shown in the following typical brand:

136	RE	Manufacturer	2003	III or 3
(Weight)	(Section)	(Mill Brand)	(Year Rolled)	(Month Rolled)

(2) The method of hydrogen elimination shall be located in the brand when a hydrogen elimination method other than Vacuum Treated (VT) is used.

(b) The web of each rail shall be hot stamped a minimum of three times per rail (short rails must contain a minimum of one full stamp) on the side opposite the brand, and shall not occur within 2' of either end of rails, and in accordance with the following requirements:

(1) The data shall be shown in the following typical stamping. The height of the letters and numerals shall be 5/8".

SS, HH, LA, IH or LH	297165	PSTU	12	BC
(Rail Type)	(Heat Number)	(Rail Letter)	(Strand and Bloom Number)	(Method of Hydrogen Elimination, if indicated in stamping)
Notes: SS = Standard Strength HH = Head-Hardened LA = Low Alley Standard Strength IH = Low Alloy Intermediate LH = Low Alloy Head-Hardened				

(2) Rails from continuous cast blooms shall be identified by a designation for heat number, strand number, and bloom number. The rail shall be identified by an alphabetical designation beginning with “P”, and succeeding “S”, “T”, “U”, etc., consecutively, or any other identification of the position of the rail within the cast, as agreed between the purchaser and manufacturer.

(c) Markings:

(1) High-strength rails shall be marked by either a metal plate permanently attached to the neutral axis, hot stamped, or in the brand which gives the manufacturer, type, and/or method of treatment. Heat-treated rail shall be paint-marked orange. Alloy rail shall be paint-marked aluminum color.

(2) Non-AREMA (Industrial Quality) rails shall be paint-marked yellow.

(3) Short rails (less than 80') shall be paint-marked green.

(4) Trackwork rails shall be paint-marked white.

(5) Rail length shall be painted on the end faces or in a manner acceptable to the purchaser or manufacturer.

(6) Individual rails shall be paint-marked only one color, according to the order listed above.

(7) Industrial Quality (IQ) rails shall be permanently identified by grinding diagonally through every “RE” or other designation within the rails’ branding. Each designation brand shall be ground or milled diagonally from the top right hand corner to the bottom left hand corner, a minimum of 1/4" in width and to within 0.010" of the parent rail web surface.

(d) For further information on this subject see AREMA 2.1.6.

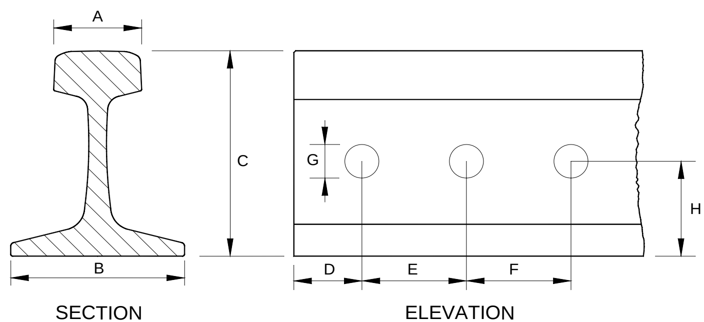
§113.2(M) Rail End Drilling and Bolt Hole Sizes

(a) Jointed rails consist of conventional length rails of 400' or less which are bolted together.

(b) CWR is continuous welded rail in strings of greater than 400' where the rails are welded by the flash butt process or by other methods as approved by MassDOT.

(c) Rail size dimensions and bolt hole drilling for typical rail sections are given in the following table.

(d) A rail and joint dimension table with some typical MassDOT rail sections is contained below.



RAIL DATA

Rail Data (Inches)														
Rail Section Dimensions In Inches	**80# A.S.**	**85# A.S.**	**100# NH**	**105# DY**	**107# NH**	**112# R.E.**	**115# R.E.**	**119# R.E.**	**130# R.E.**	**131# R.E.**	**132# R.E.**	**136# R.E.**	**140# R.E.**	**141# R.E.**
A - Head Width	2-1/2	2-9/16	2-3/4	3	2-3/4	2-23/32	2-23/32	2-21/32	2-15/16	3	3	2-15/16	3	3-1/16
B - Base Width	5	5-3/16	5-1/2	5-1/2	5-1/2	5-1/2	5-1/2	5-1/2	6	7	6	6	6	6
C - Height	5	5-3/16	6	6	6-1/8	6-5/8	6-5/8	6-13/16	6-3/4	7-1/8	7-1/8	7-5/16	7-5/16	7-7/16
D - Drilling (1st Hole)	1-15/16	1-15/16	2-1/2	2-3/4	2-1/2	2-7/16	3-1/2	3-1/2	2-3/8	2-1/2	3-1/2	3-1/2	3-12	3-1/2
E - Drilling (2nd Hole)	7	7	7	5-5/8	7	7	6	6	7	6-1/2	6	6	6	6
F - Drilling (3rd Hole)	-	-	-	5-5/8	-	6	6	6	NA	6-1/2	6	6	6	6
G - Diameter of Bolt Hole	1	1	1	1-1/16	1	1-1/8	1-1/8	1-1/8	1-11/32	1-1/8	1-1/4	1-1/4	1-1/4	1-1/4
H - Base to Center of Hole	2-3/16	2-9/32	2-39/64	2-5/8	2-39/64	2-7/8	2-7/8	2-7/8	2-3/4	3-3/32	3-3/32	3-3/32	3	3-3/32
I - Diam. of Bolt	7/8	7/8	7/8	15/16	7/8	1	1	1	1-1/8	1	1-1/8	1-1/8	1-1/8	1-1/8

Note:
[1] Source: AREMA Plan Nos. 4-1-6, 4-1-7, 4-3-13

§113.3(M) Recommended Maintenance Wear Limits for Rail

§113.3.1(M) Maximum Head and Gage Face Wear for Rail (In and Out of Track)

(a) With traffic, the rail head wears vertically and horizontally. As this wear increases, the cross section of the rail decreases. This decrease in rail section may overstress the rail causing rail failure.

(b) The following table contains the maintenance wear limits for maximum vertical wear and maximum gage face wear (both gage and field) for rail sections commonly found on MassDOT rail lines.

(c) Rail that has head and gage face wear, as given in the table below, shall be immediately removed from track and scrapped as soon as practicable.

(d) Rail replacement should be programmed prior to reaching the given maintenance rail wear limits.

§113.3.2(M) Railway Limits for the Welding of Relay Rail

(a) The table below gives the maximum head wear and gage face wear values recommended by AREMA for the welding of relay rail.

(b) Relay rail that has greater amounts of either head wear and/or gage face wear should not be welded.

(c) Maximum wear values are given for both mainlines and for other tracks to include light density mainlines, sidings, and other tracks.

Recommended Maintenance Maximum Rail Wear Limits [1]

Rail Section	New Rail Height (Inches)	Allowable Head Wear (Inches)			Allowable Gage Face Wear (Inches)		
		Mainlines	Other Tracks	New Rail Head Width[2] (Inches)	Mainlines	Other Tracks	Total Head Width Wear[3] for Mainlines and Other Tracks
80 AS	5	5/16	3/8	2-1/2	5/16	3/8	1/2
85 AS	6	3/8	7/16	2-9/16	5/16	3/8	1/2
100 NH	6	1/2	5/8	2-3/4	3/8	1/2	1/2
105 DY	6	1/2	5/8	3	3/8	5/8	1/2
107 NH	6-1/8	1/2	5/8	2-3/4	3/8	1/2	1/2
112 RE	6-5/8	1/2	5/8	2-23/32	3/8	1/2	1/2
115 RE	6-5/8	1/2	5/8	2-23/32	3/8	1/2	1/2
119 RE	6-13/16	1/2	5/8	2-21/32	3/8	5/8	1/2
130 RE	6-3/4	1/2	5/8	2-15/16	3/8	3/4	3/4
131 RE	7-1/8	5/8	1/2	3	1/2	3/4	3/4
132 RE	7-1/8	5/8	1/2	3	1/2	3/4	3/4
136 RE	7-5/16	5/8	3/4	2-15/16	1/2	3/4	3/4
140 RE	7-5/16	5/8	3/4	3	1/2	3/4	3/4
141 RE	7-7/16	5/8	3/4	3-1/16	1/2	3/4	3/4

Notes:

(1) Rail that has maximum wear as given in this table shall be removed from track immediately and scrapped as soon as practicable.
(2) Measure gage face wear at 5/8" below top of crown of railhead.
(3) Combine field and gage side wear 5/8" below top of crown of railhead. This wear column only applies to rail that has been transposed.

Rail Wear Limits for the Welding of Relay Rail[5]

Rail Section	New Rail Height (Inches)	Maximum Allowable Head Wear (Inches)			Maximum Allowable Gage Face Wear[1] (Inches)		
		Mainlines/ AREMA Class 2	Other Tracks/ AREMA Class 3	New Rail Head Width[2] (Inches)	Mainlines/ AREMA One Side Class 2	Other Tracks/ AREMA One Side Class 3	Total Head Width Wear[3]/ AREMA Both Sides Classes 2 and 3
80 AS	5	N/A	N/A	2-1/2	N/A	N/A	N/A
85 AS	6	N/A	N/A	2-9/16	N/A	N/A	N/A
100 NH	6	1/8[4]	N/A	2-3/4	3/16[4]	N/A	3/16[4]
105 DY	6	1/8[4]	N/A	3	3/16[4]	N/A	3/16[4]
107 NH	6-1/8	1/8[4]	N/A	2-3/4	3/16[4]	N/A	3/16[4]
112 RE	6-5/8	1/4[4]	3/8[4]	2-23/32	3/16[4]	5/16[4]	3/16[4]
115 RE	6-5/8	1/4[4]	3/8[4]	2-23/32	3/16[4]	5/16[4]	3/16[4]
119 RE	6-13/16	1/4[4]	3/8[4]	2-21/32	3/16[4]	5/16[4]	3/16[4]
130 RE	6-3/4	N/A	N/A	2-15/16	N/A	N/A	N/A
131 RE	7-1/8	1/4[4]	1/2[4]	3	1/4[4]	3/8[4]	3/16[4]
132 RE	7-1/8	5/16[4]	9/16[4]	3	1/4[4]	3/8[4]	3/16[4]
136 RE	7-5/16	5/16[4]	9/16[4]	2-15/16	1/4[4]	3/8[4]	3/16[4]
140 RE	7-5/16[4]	5/16[4]	9/16[4]	3[4]	1/4[4]	3/8[4]	3/16[4]
141 RE	7-7/16[4]	3/8[4]	5/8[4]	3-1/16[4]	1/4[4]	3/8[4]	3/16[4]

Notes:
(1) Measure gage face wear at 5/8" below top of crown of railhead.
(2) Combine field and gage side wear 5/8" below top of crown of railhead. This wear column only applies to rail that has been transposed.
(3) Rail classified as AREMA Class 1 or 2 may be used in any track without restriction.
(4) Rail classified as AREMA Class 3 may be used in light density mainlines, sidings, and all other tracks.
(5) AREMA values from “Rail Grading Classification by Wear Table 4-3-17.”

§113.3.3(M) Classification and Identification of Rail for Reuse (In and Out of Track)

(a) By mill inspection, rails are to be classified and identified by paint marking as follows:

Type of Rail	Marking
Standard Carbon Rails	None
Head-Hardened Rails	Orange
Rails not 39 ft. or 80 ft. in length	Green
Relay Rail Pre-Tested	Green
Relay Rail Not Tested	Yellow
Industrial Quality Rail	Per Mill

(1) High-strength rails shall be marked by either a metal plate permanently attached to the neutral axis, hot stamped, or in the brand. The information will include the manufacturer and type and/or method of treatment. (Fully heat-treated rails are no longer available and are not to be used unless approved by MassDOT Rail and Transit Division.)

(2) Individual rails shall be paint-marked only one color according to the above, or as agreed to by MassDOT Rail and Transit Division and the manufacturer.

(3) Paint marking will appear on the top of the head of one end of the rail only, at least 3' from the end.

(4) All short length rails produced shall have the length identified in a manner acceptable to MassDOT Rail and Transit Division and the manufacturer on top of the head of the rail approximately 1' from each end.

(b) Failed Rails:

(1) Rails removed from track on account of any defects listed in FRA §213.113(a), except end defects described in Paragraph (2) below, must have the top of the head noticeably damaged at the defect using a cutting torch or abrasive saw, so that they will not be mistakenly returned to service in track, or be butt welded in fabricating strings of fit CWR. These rails will also be marked with red paint on the running surface near the ends of the rail. Such failed rails, damaged as above, are to be classified for scrap in its proper category.

(2) Rails removed from track on account of end defects only, such as a bolt hole crack or head-web separation where a portion of the rail end is not physically broken out, must have the top of the rail head noticeably damaged at the location of the defect using a cutting torch or abrasive saw to insure that a rail of this type is not returned to service in track without cropping the defective end.

(3) Any rail containing longitudinal or transverse defects must be removed in its entirety (all rail between joints in bolted rail, and all rail between plant welds, between plant and field welds, or between field welds in CWR). These rails will also be marked with red paint on the running surface near the ends of the rail. The entire rail is then to be considered as scrap rail. Rails removed from track on account of any defects listed in FRA §213.113(a), except end defects described in Paragraph (2) above, must have the top of the head noticeably damaged at the defect using a cutting torch or abrasive saw, so that they will not be mistakenly returned to service in track, or be butt welded in fabricating strings of fit CWR.

§113.3.4(M) Transposing and Turning Rail on Curves

(a) To obtain the maximum service life of rails on curves, the high and low sides should be transposed before horizontal wear, vertical wear or flow of metal in the head makes this impractical because of undesirable rail head stresses that may be produced leading to possible failure of the rail itself.

(b) In general, high and low sides should be transposed when the horizontal wear on the high rail is between 3/8" and 5/8" in the full body of the curve, and before the metal in the low rail flows excessively.

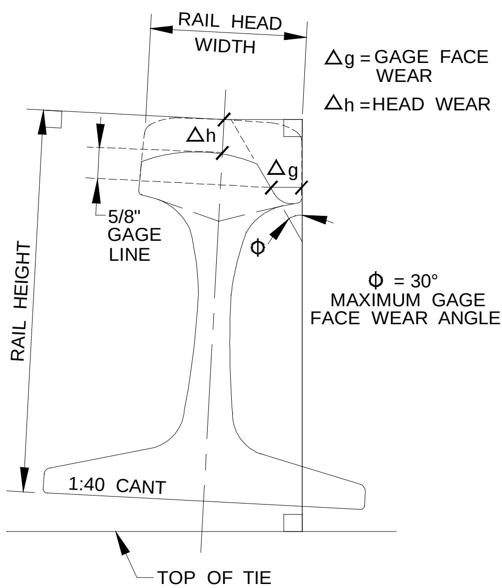
(c) In general, high side rails may be turned when horizontal wear does not exceed 1/2".

(d) 112 lb. and 131 lb. rail must not be turned or transposed without the permission of the MassDOT Rail and Transit Division.

§113.3.5(M) Gage Face Angle (Worn Rail)

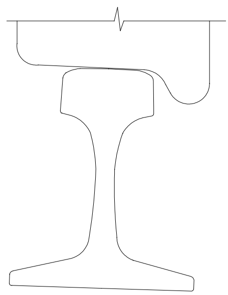
(a) When a rail is placed in track, under traffic, the gage face wears at an angle (ϕ). As this angle increases, the possibility for a wheel to climb the gage face of a rail and derail increases.

(b) As shown on the following diagram, rail replacement shall be accomplished when the gage face angle (ϕ) exceeds 30°. As the rail wear readings approach 30°, the Operating Railroad Company should make necessary plans to change out the rail.



RAIL WEAR CRITERIA

(c) For an example of new wheel and new rail interface, see the following diagram.



§113.4(M) Rail Classifications

§113.4.1(M) Defective Rails

(a) Rails removed from track on account of any defects listed in FRA §213.113(a), except end defects described in Paragraph (c) below, must be marked “NG” (no good) and a torch mark made in the head of the rail.

(b) Rails removed from track with end defects, such as bolt hole cracks or head-web separations where a portion of the rail end is not physically broken out, must have the top of the rail head noticeably damaged at the location of the defect, using a cutting torch or power saw to insure that a rail of this type is not returned to service without cropping off the defective end.

(c) “Reroller Rails/Rail Steel No. 1” are rail steel materials that are recycled as used to fabricate other steel products to include bars and shapes. Reroller rail generally has a higher value than rail scrap. Reroller rail includes:

- Standard section tee rails with a weight of 50 lbs/yard or greater which are free of all attachments;
- Rails that have no excessive pitting;
- Rails that are free of all debris (e.g., concrete, mud, asphalt, etc.);
- Rails that are not bent and twisted;
- Ferrous materials that do not contain frogs, switches and guard rails;
- Rails that do not have split heads and broken flanges;
- Pieces of CWR, provided no weld is over 9" from the end of the rail; or
- As specified by the Institute of Scrap Recycling Industries.

(d) Defective rails should be immediately removed from the right-of-way to the approved MassDOT secured scrap material storage area.

§113.4.2(M) New Rails

Class of Rail	Use
Medium-Hard Rail* Standard Rail (HB310)	In all tracks.
Head-Hardened Rail	For curves 3º and over, mainline turnouts, grade crossings, special trackwork, tunnels, and other locations as specified by the MassDOT Rail and Transit Division.

Notes:

- * Standard Rail - standard rail that conforms to latest AREMA Specifications.
- * Head-Hardened Rail - prime rail that is fully quenched and tempered in the head area only to increase hardness and strength. Head-hardened rail rolled by PST (Bethlehem Steel Company) will be marked "HH" to the right of the heat number. Head-hardened rail rolled by Rocky Mountain Steel Mill (CF&I Company) will be marked "DH" to the right of the heat number.
- * Head-hardened markings furnished by any other manufacturers shall be approved by the MassDOT Rail and Transit Division.

§113.4.3(M) Cropped or Relay Rails

(a) Rails removed from track having only end defects, such as bolt hole cracks or head-web separations within joint bar areas, may be used without restrictions after defects have been eliminated by cropping (see §113.11(M)).

(b) Relay rail should be checked against the rail wear table given in §113.2.1(M) prior to installation.

(c) Any relay rail installed in main track that carries passenger trains, or is a hazardous material route, shall be inspected for internal rail defects if the operating speed is Class 3 or higher.

(d) If a valid search for internal defects cannot be conducted before expiration of time or tonnage limits given in FRA §213.237(a) or (c), reduce operating speed to a maximum 25 MPH until such time as the valid search can be made.

§113.5(M) Disposition and Shipment of Rails

(a) Rails released from renewals and retirements must be disposed of as authorized by MassDOT.

(b) Other track materials (OTM) must be removed from the individual rails before loading rail onto railcars or trucks (see §100.3(M)).

(c) For shipment, relay rails may be loaded head up with wood stripping between layers.

§113.6(M) Distributing Rail

(a) Rails and OTMs should be unloaded in a position as close as possible for laying to minimize further handling.

(b) Rails should be placed parallel with the track on their base to avoid excessive bending or damage. Care should be taken to avoid placing rails on manhole covers, on signal cables and conduits, or close to air lines.

(c) Rail is not to be stored between the running rails unless conditions do not allow rail placement outside the track off the ends of the ties. Rail heads should not be above the running rail.

(d) CWR ends must be offset and blocked to allow for thermal expansion.

(e) In yards and at locations where employees must walk close to the track, rail should be placed as near to the ends of ties as possible to avoid obstructing walkways.

(f) Any time rail and OTM is distributed along the right-of-way, the Transportation Department must be notified so as to include in a Division Notice.

§113.7(M) Preparation and Care

(a) As far as practicable, track should be placed in good line and surface prior to rail renewals. Programmed tie renewal shall be accomplished before laying rail. Track to be laid with CWR should be fully ballasted, and preferably, programmed tie renewals should be completed in advance of rail laying.

(b) Rails should be examined prior to laying in track to detect any sharp bends, damage, or surface conditions that will make them unserviceable.

(c) Care of rail should be taken the day on which it is laid, so that no damage to rail or fastenings will result from continued use under normal traffic. Loose ties should be tamped to a good bearing under the rail immediately behind rail laying operations.

§113.8(M) Laying Jointed Rails

(a) Jointed rails should be laid, one at a time, with space allowance for expansion being provided between rail ends in accordance with the following table:

Jointed Rail Expansion Tables	
39' Rails	
Rail Temperature (°F)	**Rail End Space (Inches)**
Below 6	5/16
6 to 25	1/4
26 to 45	3/16
46 to 65	1/8
66 to 85	1/16
Over 85	None

78' or 80' Rails	
Rail Temperature (°F)	**Rail End Space (Inches)**
Below 30	5/16
31 to 45	1/4
46 to 60	3/16
61 to 72	1/8
73 to 85	1/16
Over 85	None

(b) Rails greater than 80' and less than 400' in length, must be expanded and anchored as CWR.

(c) To insure the required space allowance, rail ends should be brought squarely together against approved expansion shims of proper thickness and the rail joints applied before spiking and anchoring.

(d) Space between rail ends for insulating joints (paper and poly types) should only be sufficient to permit insertion of standard end posts.

(e) An approved rail thermometer shall be used. The person in charge shall see that rail temperature is checked frequently and that proper rail expansion shims are used.

(f) Jointed rails should be laid, one at a time, with space allowance for expansion being provided between rail ends.

(g) To insure the space allowance required, rail ends should be brought squarely together against approved expansion shims of proper thickness and the rail joints bolted before spiking.

(h) An exception to the requirement of laying one rail at a time is to expedite rail installation no more than 180' of rail (5 @ 39' rails) may be bolted together prior to being installed in track, provided that the proper rail end spaces are maintained according to §113.9(a) above.

(i) Space between rail ends in insulated joints should only be sufficient to permit installation of standard end posts.

(j) An approved magnetic rail thermometer shall be used to determine the rail temperature. The thermometer is to be attached to the web of the rail that is shaded from the sun’s rays for a minimum of 5 minutes until an accurate temperature reading can be achieved. Rail thermometer should be placed on the smooth surface of the web and not on any raised brand.

(k) Rail should be laid with joints staggered 13’ to 15’. Permissible variations are as follows:

   (1) Through turnouts and at insulated joints;

   (2) Rails laid with the joints of one line of rail opposite the middle of rails in the other line in accordance with former standards need not be relocated until out-of-face rail renewals are made; and

   (3) At other locations as directed by the MassDOT Rail and Transit Division.

(l) Rails less than 18' in length should not be used in main tracks, except that rails not less than 14' may be used for:

   (1) Connections within turnouts and crossovers;

   (2) Temporary closures;

   (3) Temporary replacement of broken rails. Rails not less than 14’ in length used in accordance with previous standard practice need not be removed until rails are changed or re-laid.

(m) Placing bolted joints in or closer than 30’ from the edges of road crossings, within the limits of switch rails, frog guard rails, or the ends of open deck bridges, trestles, or viaducts is prohibited (unless approved by MassDOT Rail and Transit Division).

(n) Rails of the same section should be used on open deck bridges, through road crossings, through paved track areas of station platforms, through areas of direct fixation track, and to the greatest extent possible in turnouts and crossovers.

(o) Rails of unequal wear and different sections must be brought to an even surface at joints on the tread and gage side of the rail by welding. When shimming is required to run off the difference in height of rails, the requirements of §129.0(M) must be met.

(p) The use of shims or spring washers between the web and the joint bar to align the gage sides of rail heads, or the use of acetylene torches, or grinding to manufacture, or change the dimensions of compromise joints, is prohibited. Adjustments to the tread and gage side of the rail head must be accomplished by:

(1) Compromise joints of approved design.

(2) By welding the rail head.

(q) When necessary to make a temporary connection for the passage of a train at normal speed, the connection must be made with a piece of rail not less than 14' long. Use compromise or standard joints with the full number of bolts and with all rail holding spikes driven. Use of switch points to make temporary connections when laying rail is prohibited.

§113.9(M) Rail End Bolt Holes

(a) Holes must be drilled in accordance with AREMA recommended standard practice and the following:

(1) Bolt holes shall be drilled with the joint bars removed by marking the location of the center of the hole with a proper size template block or by drilling through an approved template.

(2) When bolt holes are drilled, a uniform feeding pressure should be maintained as per manufacturer's instructions.

(3) An environmentally sensitive lubricant should be used throughout the drilling process.

(4) Bolt hole sizes and drillings are found in the rail end drilling table given in §113.1(M).

(5) After drilling is completed, bolt holes should be brushed out and inspected. Any burrs or chipped edges should be removed by chamfering or filing to a smooth edge around the entire circumference of the bolt hole.

(6) If jointed rail is to be welded, rail ends should be drilled in such a manner as to provide for closure by field welding (no edge of hole closer than 6" to the joint).

(7) In those instances where the joint will not be welded, all holes in the joint bar will be drilled and fully bolted.

§113.10(M) Cutting and Electric Arc Welding of Rail

(a) For cutting of tight rails in CWR see Appendix A, "Continuous Welded Rail (CWR) Procedures."

(b) The tools which may be used for cutting rails are listed below:

(1) Power saws with approved guide attachments and proper PPE.

(2) Gas cutting torches, in emergency only in accordance with FRA §213.122.

(c) Electric arc welding is prohibited on any portion of the rail, except as listed below:

(1) Welding of engine burns. Engine burns deeper than 3/8" should not be welded. If there are more than four engine burns within a 39' rail, the rail should be changed out.

(2) Application of welded bonds.

(3) Top of rail within limits of joint bars (batter and rail ends).

(4) Gas welding of rail is prohibited.

(d) Any rail damaged by torches must be promptly removed from track.

(e) Except for the welding of engine burns in accordance with approved methods, and except for application of welded bonds, gas or electric arc welding is permitted only on the top of the rail within the limits of the joint bars.

§113.11(M) Bonding Rails for Track Circuits

(a) Except in an emergency where rails are bonded for track circuits, no rail bonds shall be broken or rails removed unless a Signal Maintainer is notified or present.

(b) Signal bonds shall not be applied to the rail web or base; only on the rail head.

(c) In an emergency, a broken rail, switch point, or frog may be renewed without waiting for the Signal Maintainer. In such cases, the joints shall be tightened to make as good contact as possible with the rails and the Signal Maintainer notified that the rail bonds have been broken.

(d) If a broken rail is replaced within the starting circuit of automatic highway crossing protection, the track shall not be restored to service until all trains approaching the crossing have been:

   (1) Instructed to be prepared to stop prior to passing over the crossing involved; or

   (2) Until a qualified person under FRA §213.7(d)(1) is provided to move train traffic at the crossing; or

   (3) The Signal Maintainer has applied all rail bonds and verified the continuity of the circuit.

§113.12(M) Maintenance of Rail by Grinding

(a) Rail grinding must be accomplished with profile grinders or production grinding units.

   (1) Hand grinding should be limited to small areas where the use of profile grinders is not practical.

   (2) Out-of-face grinding must be performed with production grinding units.

(b) Production grinding is required to remove surface anomalies such as scale, flakes, checks, shells, and corrugations on the rail head and to re-profile the rail head.

(c) In special trackwork a combination of production grinding and hand grinding may be required.

(d) Grinding of rail should be performed at regular intervals based on the condition of the rail, location (such as grades and curves), the number, and type of trains, and the accumulated tonnage at a particular location.

(e) All grinding on wooden open deck bridges shall be approved by MassDOT Rail and Transit Division before any work begins. Rail grinding on bridges (ballast deck) is permitted provided that proper precaution is taken against fire as given below:

   (1) Grinding shall only be performed when there is no highway or river traffic directly under the area to be ground.

   (2) The rail grinding crew has a supply of water and other fire suppressants to protect against fire.

   (3) After grinding, the entire structure is re-inspected for possible “hot spots” or fire.

   (4) Production grinding of rail on timber trestles is prohibited.

(f) High rail truck with water tank shall follow rail grinder to inspect for hot spots and slag.

(g) MassDOT Rail and Transit Division shall approve lubricants and/or friction modifiers to be used after grinding curves on:

   (1) Gage face on the high rail

   (2) Top of rail (TOR) on the low rail.

§113.13(M) Repair of Welds and Rail Head Depressions by Welding or Grinding

(a) Field and shop welds shall be inspected for batter. Maintenance welding and grinding shall be performed as required.

(b) The depth of low spots and depressions around welds shall be measured with a 36" straight edge and taper gauge. Maintenance welding and grinding shall be performed as required.

(c) The preferred method of removing low spots, low areas, and engine burns (but NOT engine burn fractures), in the rail head profile is by building up the rail head by welding.

(d) Any engine burn should be repaired as soon as practicable before rail and tie damage occur. Engine burns 3/8" or greater require removal and replacement of the rail.

§113.13.1(M) Cross Cutting (Slotting) of Bolted Joints

(a) Permanent bolted joints shall be inspected and rail ends slotted as required to remove metal flow and prevent end chipping.

(b) When rails are replaced at the location of a permanently bolted joint, the rail ends should be slotted.

(c) The frequency of grinding or slotting rail ends at permanently bolted joint locations may increase due to traffic and as other local conditions require.

§113.14(M) Passing Trains Over Broken Rails and/or Pull-Aparts

(a) When passing trains and/or locomotives over broken rails and/or pull-aparts, the Operating Railroad Company MOW personnel shall comply with the following information.

(b) Persons not fully qualified to supervise certain renewals and inspect track as required in Paragraph (a) of this section, but with at least one year of MOW or signal experience, may pass trains over broken rails and pull-aparts provided that:

   (1) The track owner determines the person to be qualified and, as part of doing so, trains, examines, and re-examines the person periodically within two years after each prior examination on the following topics as they relate to the safe passage of trains over broken rails or pull-aparts: rail defect identification, crosstie condition, track surface and alignment, gage restraint, rail end mismatch, joint bars, and maximum distance between rail ends over which trains may be allowed to pass. The sole purpose of the examination is to ascertain the person's ability to effectively apply these requirements and the examination may not be used to disqualify the person from other duties. A minimum of four hours training is required for initial training;

   (2) The person deems it safe and train speeds are limited to a maximum of 10 MPH over the broken rail or pull apart;

   (3) The person shall watch all movements over the broken rail or pull apart and be prepared to stop the train if necessary; and

   (4) Person(s) fully qualified under FRA §213.7 are notified and dispatched to the location promptly for the purpose of authorizing movements and effecting temporary or permanent repairs.

§115.0(M) RAIL END MISMATCH

Rail shall be maintained so that the mismatch of rails at joints may not be more than that prescribed in the following table:

Rail End Mismatch Maintenance Limits		
Class of Track	Any mismatch of rails at joints may not be more than the following:	
	On the head of the rail ends (Inches)	On the gage side of the rail ends (Inches)
1 – 5	1/8	1/8

Rail End Mismatch

§117.0(M) RAIL END BATTER/BEVELING OF RAIL ENDS

(a) Rail end batter is the depth of depression in the rail head near the end of the rail. It is measured by placing an 18" straight edge on the head of the rail at the rail end, without bridging the joint and measuring with a taper gauge the maximum distance between the bottom of the straight edge and the top of the rail head.

(b) When rail end batter is detected, it should be monitored and corrected when reaching the limits given below:

(1) See the following table:

Rail End Batter Maintenance Limits		
Class of Track	Rail End Batter May Not Be More Than (Inches):	Crop Bolt Holes and Rail Ends to Remove Batter if Batter Exceeds Values Below (Inches):
1 - 2	1/4	3/8
3 – 5	1/8	1/4

(2) Rail end batter should be repaired by a qualified welder using an electric arc welder.

(3) In Classes 3-5, rail ends that have 3/8" or more rail batter shall not be welded and shall be cut out and scrapped.

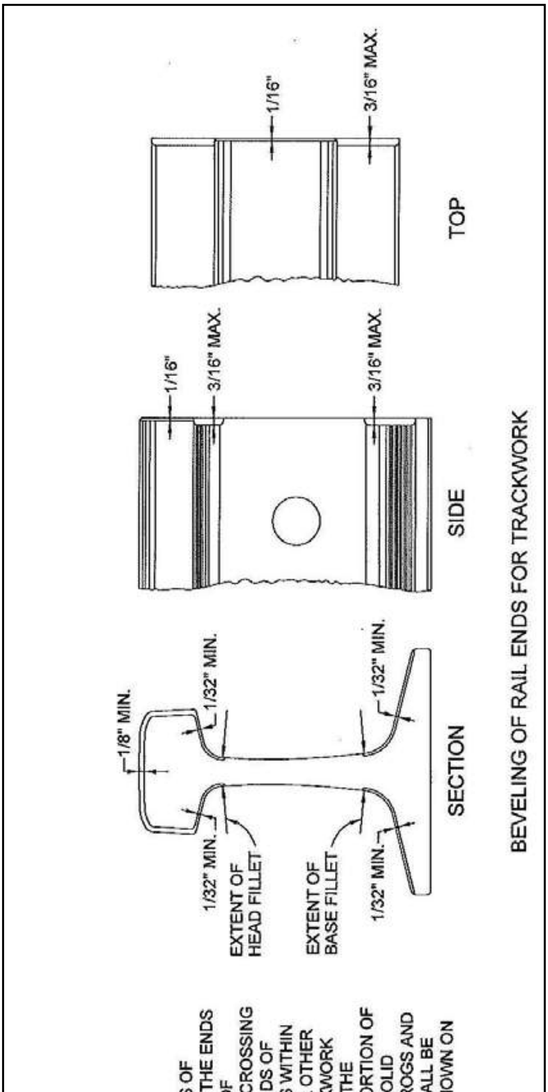
(4) After welding, rail ends shall be ground and slotted as shown in Paragraph (c).

(c) To reduce chipping or spalling due to overflow of steel under traffic, the rail end faces should be cross-cut by grinding with a 1/8" beveled slotting wheel to a depth of not less than 3/16" below the surface of the head.

(1) The maximum cut should not be wider than 1/8".

(2) If the rails are not in contact, the overflowed metal should be removed from both end faces by grinding 1/16" from the ends of both rails.

(3) See following figure as developed by AREMA.



BEVELING OF RAIL ENDS FOR TRACKWORK

§118.0(M) RAIL LUBRICATION

(a) The gage face of the running rail in track or in special trackwork must be lubricated as follows:

   (1) Running rail in curve locations where there is significant gage face wear on the high rail, or significant flow on the low rail, shall be lubricated with a wayside lubricator or as specified by the MassDOT Rail and Transit Division.

      (i) Lubricate high rail gage face

      (ii) Lubricate low rail top of rail

   (2) When changing switch points, stock rails, and frogs in heavily used routes in interlockings, regardless of turnout size or type, lubricate new components by hand.

   (3) After grinding or welding repairs to switch points and/or frogs, lubricate components by hand.

   (4) When production grinding, ensure that in curves both rails are lubricated on the last grinding pass.

(b) When lubricating rail, care should be taken to control the amount of lubricant being used to avoid migration to the running surface of the rail.

(c) At wayside lubricator locations, install geotech fabric to prevent fouling of ballast. Dispose of fabric in accordance with local, State, and Federal regulations.

(d) Locate lubricators no closer than 500' from grade crossings with active warning devices.

(e) When installing lubricators, care should be taken not to install steel-mesh hoses in signal territory.

(f) Both rails should be lubricated as excessive lubrication of the high rail and poor lubrication of the low rail can produce high lateral forces and low rail rollover resulting in derailment.

(g) Use only approved environmentally-friendly lubricants per manufacturer's recommendations.

§119.0(M) CONTINUOUS WELDED RAIL PROCEDURES

See Appendix A, "Continuous Welded Rail (CWR) Procedures."

§121.0(M) RAIL JOINTS

§121.1(M) Field Welding of Rail Joints

(a) When performing rail maintenance, reduce the quantity of joints in track by laying CWR and field welding joints wherever possible.

(b) Thermite and flash butt are acceptable methods for in-track field welding.

(c) Thermite and flash butt welding shall be performed in accordance with the supplier's recommended procedure.

(d) When it is necessary to install plug rails, the plug rails should be at least 13' in length.

(e) Bonded insulated joint rail assemblies shall be field welded.

(f) Whenever possible it is desirable to field weld all turnouts and special trackwork.

(g) If it becomes necessary to apply temporary joint bars in CWR, the end bolt hole in each rail must not be drilled, as this would prevent subsequent field welding. Additional rail anchors must be applied to this joint in accordance with §125.0(M).

(h) Field welding on open deck bridges is permitted provided that proper precaution against fire is taken and only allowed with the prior approval of MassDOT Rail and Transit Division.

§121.1.1(M) Thermite Field Welding

(a) When using the thermite field welding process:

- (1) Ensure that rail ends are secured against movement from thermal expansion or contraction, or from other causes. Use a hydraulic expander to maintain the rail end gap and rail alignment.
- (2) Saw cut rail ends to be welded. If a torch cut rail is to be welded at least 2" of rail behind the torch cut must be cut off with a saw before the weld is made.
- (3) No thermite weld shall be made:
  - (i) If the air temperature is below 32°F.
  - (ii) In inclement weather (rain or snow).
- (4) Required location of field welds:
  - (i) Within 14' of a field weld in the same rail.
  - (ii) Within 4' of a plant weld in the same rail.
  - (iii) Within 10' of the centerline of any joint (except bonded insulated joints where no weld shall be made within 7' of the centerline of the joint).
  - (iv) Within 6" of a bolt hole.
  - (v) Within 6" of a weld that has been cut out.
  - (vi) On or within 4-1/2" of a tie plate or concrete tie rail seat.
  - (vii) Within a grade crossing without the permission of MassDOT Rail and Transit Division.
- (5) General welding procedures are as follows:
  - (i) Prior to installing the molds, make a visual inspection of the two rail ends to ensure there are no bent rails or other defects such as cracks, splits, pipes, etc., which could cause, or later be interpreted as a defective weld.
  - (ii) Check the gap to ensure that it meets the specification of the weld kit manufacturer.
  - (iii) Align the rail ends.
  - (iv) Remove foreign matter, luting compound, and/or moisture from the molds or crucible.
  - (v) If a hydraulic expander has been used, do not release it until the weld has cooled to 500°F or less. The expander shall be released gradually.
  - (vi) No train traffic shall be allowed to pass over the weld, nor shall there be any disturbance of the track or rail in the area of the weld, until the weld has cooled to 500°F or less.
- (6) The grinding and finishing of the weldment are as follows:
  - (i) The top and sides of the head of the rail at the weld shall be ground flush with the parent metal.
  - (ii) The weld in the web and base should be ground ***only*** to remove notches created by offset conditions, sharp protrusions, and gouges. These should be blended into the contour of the weld collar to eliminate stress risers.
  - (iii) In the case of continuously supported rail, the bottom and sides of the base must be ground flush with the parent metal.

(iv) Overheating the rail when grinding must be avoided. If a weld has cooled to below 500°F it must be ground so as to not increase the temperature back above 500°F.

(v) Finish grinding shall be conducted when the weld temperature is less than 200°F.

(7) Welds shall be identified on the rail with a unique number and the date using a highly visible paint or paint stick to allow identification of a particular weld.

(8) Welds shall be inspected once completed and ground.

(i) A visual inspection shall be conducted immediately. This inspection shall look for voids, nicks, gouges, sharp protrusions, or other obvious surface defects.

(ii) An inspection of the alignment of the weld shall be conducted using a 36" straight edge centered on the weld. The weld will meet the following criteria:

1. There shall be no dip.
2. The crown shall not measure more than 3/50" at a point 18" from the weld.
3. The horizontal misalignment (measured by placing the straight edge on the running side of the head) shall not measure more than 3/50" at a point 18" from the weld or at the weld if the misalignment causes a gap at the weld.

(9) An ultrasonic inspection of the weld shall be conducted within 24 hours of the completion of the weld.

(b) Field welding on open deck bridges is permitted provided that all the following conditions are met:

(1) A qualified contractor and/or Operating Railroad Company individual using a 17 lb. dry chemical ABC extinguisher is available to protect against fires.

(2) A qualified contractor and/or Operating Railroad Company individual must be present for a period of at least one hour after the last field weld is finished and ground.

(3) An extra 17 lb. ABC extinguisher must also be readily accessible as a backup.

(4) While extinguishing any fires, the qualified contractor and/or Operating Railroad Company individual must stand upwind and aim the chemical at the base of the fire.

(5) A qualified contractor and/or Operating Railroad Company individual must be present during the entire welding operation from beginning of welding process to at least one hour after the last field is finished and ground.

(6) Flash butt welding, shearing and grinding shall only be performed when there is no highway or river traffic directly under the area of the welding.

(7) Bridge timber spacing may be more restrictive than that of ballasted track. Welding shall not be performed if the tie crib is less than 5-1/2" in width or as approved by MassDOT Rail and Transit Division.

(8) Welds on open deck bridges must be made as close to the center of the crib as possible. The minimum distance between center of weld and edge of tie shall be 2-3/4".

(9) After welding, the entire structure should be inspected for possible “hot spots” or fire.

§121.1.2(M) Electric Flash Butt Welding

(a) In general, thermite field requirements apply to this process along with the following additions:

(1) All electric flash butt welding consumes rail (1-1/4" – 1-1/2" at each weld location).

(2) The weld must be at least 400' from grade crossings, turnouts or other fixed objects in the track.

(3) Anchors or resilient fasteners must be removed from at least 200' of rail on both sides of the weld before the weld is made.

(4) Care must be taken to avoid skewing ties by binding the rail against the shoulder of the tie plates when the rails are pulled together.

(5) Care must be taken to avoid damaging elastomeric tie pads by sliding the rail through the tie seat area of concrete ties when the rails are pulled together.

(6) If new rail is to be welded by the electric flash butt welding method, this decision should be made before the rail is laid and distressed so that the right amount of expansion can be calculated.

(7) When CWR strings in track are laid in track and expanded to reach a preferred rail neutral temperature (PRNT), the actual required expansion shall be reduced if the CWR strings are to be electric flash butt field welded. The amount of expansion required for a particular CWR string shall be calculated using Appendix A, “Continuous Welded Rail (CWR) Procedures.” The amount of rail to be consumed when making the two electric flash butt field welds at each end of the string shall be subtracted from the amount calculated in Appendix A, “Continuous Welded Rail (CWR) Procedures.” The resulting “net” rail expansion shall be achieved in the field when distressing and/or laying the string before welding.

§121.2(M) Bolted Rail Joints

(a) Rail ends shall be fastened together by bolted standard, compromise, or insulated joints.

(b) The use of shims or spring washers between the web of the rail and the joint bar to align the gage sides of rail heads is prohibited.

(c) The use of acetylene torches or grinding to reconfigure or change the dimensions of standard and/or compromise joint bars is prohibited.

(d) Compromise joint bars of an approved design shall only be used to join rails of the respective sections.

(e) If rail end mismatch exists after applying approved joint bars, the rail head and gage face surfaces may be adjusted by electric arc welding the smaller rail and grinding to finish the weld. Do not grind the larger rail section.

(f) Each rail joint, insulated joint, and compromise joint must be of a structurally sound design and dimensions for the rail on which it is applied.

(g) If a joint bar is cracked, broken, or because of wear allows excessive vertical movement of either rail when all bolts are tight, the joint bar shall be changed.

(h) Each joint bar must be held in position by track bolts tightened sufficiently to provide firm support for abutting rail ends and to allow longitudinal movement of rails in the joint to accommodate expansion and contraction due to temperature variations.

(i) In track with conventional jointed rail, each rail shall be bolted with all joint bar bolt holes filled.

(j) If a permanent joint connection is made between CWR and bolted rail, all joint bar holes must be filled.

(k) No rail or joint bar having a torch cut or burned bolt hole may be used in track.

(l) When a bolt is changed in a joint in Track Classes 1-5, or a frog bolt is changed, then all bolts in the connections shall be checked and retightened as required.

(m) Whenever possible, new bolts, nuts, and spring washers should be used when new or relay joint bars are applied.

(n) Lubricate joint bars with environmentally-approved lubricate. Tighten all bolts, working from center of joint bars outward. During this final tightening, tap the toes of the bars inward with a sledgehammer.

(o) In locations of elastic fasteners, the appropriate clip will be used to properly fasten the ties through the joint area.

(p) Description of joint bars:

(1) Standard bolted rail joints consist of either head free or head contact standard bars or compromise joint bars held in position by track bolts having sufficient tension to firmly support abutting rail ends, but not too tight to prevent longitudinal movement in joints to accommodate expansion and contraction due to variation in rail temperature.

(2) Head free bars must have the inner surface of the head of the bar held tightly against the rail head fillet with the heel of the bar standing out the proper distance from the base fillet, where all of the “draw-in” for wear is concentrated.

(3) Head contact bars must have the top surface of the bar held tightly against the fishing surface under the rail head outside of the rail head fillet area. Bars must be secured in a vertical position without “cocking.”

(q) Application of standard bolted joint bars will be as follows:

(1) Joint bars shall be applied with their full number of bolts, nuts, and spring washers according to the standard plans and specifications.

(2) New bolts, nuts, and spring washers should be used when new or reformed joint bars are applied or renewed out-of-face.

(3) Grease shall be applied to the fishing area of the rails, for the full length of the joint bars.

(4) When initially applying joint bars, the bolt tension should be brought in the range of 20,000 to 25,000 lbs. and for subsequent retightening from 15,000 to 20,000 lbs. This may be approximated by an average individual with a 36" track wrench.

(r) Application of head free joint bars will be as follows:

(1) Set bars in position, insert all bolts, and apply spring washers and nuts by hand.

(2) Tighten up the two center nuts with a power track wrench in high gear without fully tightening to avoid locking bars in an improper position.

(3) Strike the bead of the heads of both inside and outside bars at both ends with a hammer to force the inside faces of the bars tightly against rail head fillets. Do not strike the toe of the bar, as this tends to force the toe of the bar outward.

(4) Tighten remainder of bolts from center of joint bars outward in high gear.

(5) Tighten all bolts in low gear, working from center of joint bars outward. During this final tightening drive the toes of the bars inward by tapping with a spike maul or sledge.

(6) By following the above procedure, proper contact will be obtained between the inner face of the bar and the rail head fillet. Also, the heel of the bar will stand out the proper distance from the rail base fillet.

(s) Application of head contact joint bars will be as follows:

(1) Set bars in position on rail; insert all the bolts, nuts, and spring washers by hand.

(2) See that the bars are in a vertical (uncocked) position as one of the center bolts is tightened by:

(i) Inserting a bar or drift pin in a bolt hole (necessary only when applying a 131 lb. bar).

(ii) Tapping toes of joint bars as bolt is tightened.

(3) Tighten all bolts, working from center of joint bars outward. During this final tightening drive the toes of the bars inward by tapping with a spike maul or sledge so that their vertical position is maintained.

(t) Maintenance of joints:

(1) Drilled ends of new rails are to be ground to remove burrs at the mills.

(2) To avoid chipping or spalling under service due to overflow of steel, the rail end faces should be cross-cut by grinding with 1/8" wheel to a depth of not less than 3/16" below the surface of the head. If the rails are not in contact, the overflowed metal should be removed from the end face of each rail. If the rails are in contact, only one pass should be made removing approximately 1/16" from each rail.

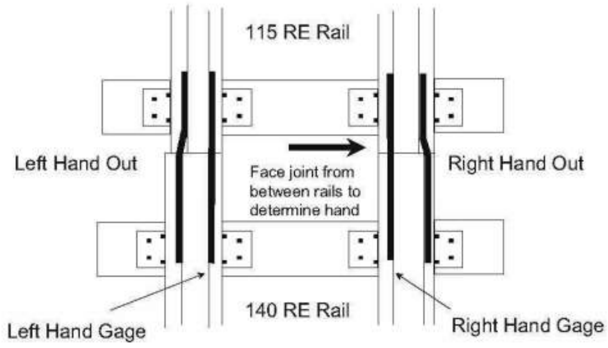
(3) When bolted joints are applied, other than insulated joints, the bolts should be tightened at the time they are applied, retightened within a week and again within a month after application.

(4) Bolts should be retightened periodically at intervals of not more than 1 year and in all cases following program track raising or surfacing.

(5) To prevent undue rail stress on account of expansion or contraction at the changes of seasons and wide temperature changes, sufficient joint bars should be loosened to permit the rail to adjust itself, immediately after which bolts should be retightened. Where necessary, a piece of rail should be cut out to avoid heat kinks or buckling of track.

(6) Wear in fishing spaces of rail should be compensated for by the application of oversized joint bars.

(u) Compromise joints are specified as left or right hand as shown in the following diagram. To determine where a left hand (“LH”) or right hand (“RH”) lays, stand in the center of the track and face the joint to be compromised.



Compromise Joint Example

§121.3(M) Insulated Rail Joints

(a) For new work or rail renewals in track circuit territory, insulated joints shall be located as follows:

  (1) Insulated joints shall be staggered not more than 60" nor less than 24".

  (2) Insulated rail joints at highway grade crossings shall be located in accordance with the material supplier's standard plans.

(b) For the application of Bonded Insulated Joints (Glued Insulated Joints), see the following:

  (1) Glued plug insulated joints are required on all concrete tie tracks.

  (2) When utilizing insulated plug rails, install the shortest plug rail available so as to minimize the number of joints and/or wells added.

  (3) Conventional rail joints adjacent to bonded insulated joint rails should be field welded.

  (4) All bonded insulated joints are to be installed as suspended joints. If it is absolutely necessary to install the insulated joint as a supported joint on a wood crosstie, an approved type rubber tie plate must be used under the joint. The end posts should not project above or beyond rail heads and should be trimmed with a hack saw.

  (5) Double shoulder tie plates or elastic fastener tie plates should be used on the two wood crossties supporting suspended bonded insulating joints.

  (6) Rail holding spike heads must be in reverse position and must be carefully driven to ensure that spike head is not in contact with the bar, which could result in the joint's being short circuited. All bonded insulating joints will have plate holding spikes installed.

  (7) Joints installed with elastic fasteners shall have the correct clips (modified "e" clip) applied to prevent possible damage to the joint.

  (8) No attempt should be made to tighten bolts in bonded insulated joints. In the event the bolts in the joint become loose, the joint should be replaced.

(9) Any rail head overflow at a bonded insulated joint is to be removed by grinding. Extreme care must be exercised to ensure that the end post is not damaged. The overflow should be ground only to the rail end, so that the joint gap will not be greater than the original gap. A cross grinder/slotter should not be used to remove the overflow.

(10) Bonded insulated joints will be considered as welded rail for purposes of compliance with the anchoring requirements of §125.1(M).

(11) Glued plug insulated joints shall be used in CWR (unless approved by MassDOT Rail and Transit Division).

(c) For the application of Polyurethane Coated Steel Insulated Joints (Poly Joints) see the following:

(1) Polyurethane coated (poly) steel insulated joints may be used permanently in track where the use of a bonded insulated jointed rail is not practical.

(2) Whenever possible, poly insulated joints are to be installed as suspended joints.

(3) The top of the poly joint must be set first into the fillet area of the rail. Bolts should be applied and tightened from the center out to the end of the bar.

(4) Rail holding spikes shall be reversed and not driven up against the poly joint.

§123.0(M) TIE PLATES

(a) Tie plates shall be installed and centered under running rails on all wood crossties, switch timber, and bridge timber.

(b) The preferred tie plate is a 14" double shoulder canted (1:40) plate (DSC).

(c) Tie plates with different cants and flat plates shall not be mixed.

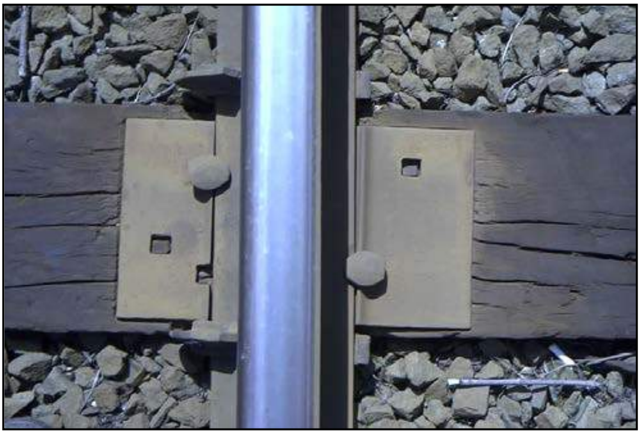
(d) Canted tie plates shall be installed so that the rail cants towards the centerline of track.

(e) Tie plates must be placed square and tight to the base of the rail and no portion or part of the shoulder can be under the base of the rail.

(f) No metal object that causes a concentrated load by solely supporting a rail shall be allowed between the base of the rail and the bearing surface of the tie plate (e.g., tie plate shoulders, spikes, ballast, etc.).

Tie Plate with Anchors Applied Correctly

Tie Plate with Anchors Overdriven



Box Anchored Ties with Anchors Applied Correctly

§124.0(M) TIE PADS

The use of tie pads, under the tie plates on open deck bridges, may be used only with the approval of the MassDOT Rail and Transit Division.

§125.0(M) RAIL ANCHORS/ELASTIC FASTENERS

§125.1(M) Anchor Placement

(a) Rail anchors shall be applied as follows:

- (1) Anchors shall be applied on both rails and on the same side of the tie. Where special applications may be necessary, other arrangements may be used with permission of the MassDOT Rail and Transit Division.
- (2) Wherever practicable, rail anchors shall be applied from the gage side of the rail.
  - (i) In turnouts, drive on type anchors shall be applied to switch stock rails from the field side of the track. Care must be taken in application of anchors so as not to foul switch rods.
- (3) When adjusting or laying rail, the necessary anchor pattern shall be applied immediately as the rail is adjusted.
- (4) Anchors should be fit tightly against sound ties.
- (5) When ties at a joint cannot be anchored because of interference with a joint bar, there shall be no anchors applied to the affected joint.

§125.2(M) Fasteners Required

(a) Rail anchors should be driven just far enough so that the locking lip or groove of the anchor snaps into place on the base of the rail.

(b) A sufficient number of anchors must be applied in a pattern to effectively control longitudinal rail movement. See next pictures for typical fastening and anchoring systems.

Elastic Fastener: Pandrol Fast Clip

Elastic Fastener: Pandrol E-Clip

(c) Insufficient anchors may result in longitudinal rail movement and allow changes in rail neutral temperature (RNT) in CWR.

(d) The movement of rail can result in changes in line and surface, which may create a hazardous condition.

(e) Additional anchors must be applied if there is a standard anchor pattern and there is evidence that rails are still moving longitudinally under traffic.

(f) It should be recognized that when track is raised out-of-face, the resistance to longitudinal movement is reduced and additional anchors may be required to avoid undue rail and tie movement.

(g) Basic anchor requirements in CWR track:

- (1) Every other tie shall be box anchored in all CWR tracks.
- (2) Box anchor every tie in curves 3° and over.
- (3) Additional anchors may be added at designated locations in anchored track or elastic fastener territory as required if longitudinal movement of the rail is detected.

(h) On main tracks the number of anchors to be applied when CWR is laid and maintained is as follows:

- (1) When using rail anchors, box anchor every wood tie 200' in each direction from:
  - (i) Ends of CWR strings.
  - (ii) All joints to include glued plug insulated joints.
  - (iii) Turnouts, crossovers, and other special trackwork.
  - (iv) Rail track crossings.
  - (v) Public and private highway grade crossings.
  - (vi) Transitions to locations with elastic fasteners.
  - (vii) Transitions to locations of tie type change (e.g., wood to concrete or wood to steel).
  - (viii) Open decks on bridges, where the timbers are hooked and blocked in accordance with §119.1(M).
- (2) To the extent practical, fully box anchor all ties in CWR within switch, turnout, and crossover areas.

(i) Rail anchoring systems shall be used on open deck bridges, trestles, and viaducts as determined by the MassDOT Rail and Transit Division.

(j) All jointed rail tracks require:

- (1) A minimum of 40 anchors for a 78' rail and be boxed on 20 ties.
- (2) A minimum of 16 anchors per 39' rail and be boxed on 8 ties.
- (3) A minimum of 10 anchors per 33' rail and be boxed on 5 ties.
- (4) No anchors will be placed in grade crossing panels (unless approved by MassDOT Rail and Transit Division).

(k) A fully clipped wood tie, bridge timber, or fully clipped and insulated concrete tie with an elastic fastener, is considered equivalent to a box anchored wood tie.

§125.3(M) Anchor Maintenance

(a) Ineffective anchors shall be removed and replaced when installing railing.

(b) Rail anchors must have full bearing against the tie, or tie plate, when applied.

(c) In order to avoid damage, only proper tools or machines should be used in applying and removing rail anchors.

(d) Anchors should never be applied with a spiking hammer.

(e) Anchors should not be driven along the base of the rail with a hammer.

(f) Care should be taken not to strike the rail.

(g) When the bearing of rail anchors against the tie is disturbed by renewing or re-spacing ties or replacing rail, or the anchor was not properly applied, the anchors must be taken off and then re-applied in proper position. All anchors removed must be re-applied, and defective or broken anchors must be replaced as necessary.

(h) Proper opening between rail ends in jointed rail is maintained by the use of rail anchors.

§125.4(M) Anchor Use

New or relay rail anchors may be used at any location on the MassDOT system as long as they are designed for the rail section to which they are applied and perform as intended.

§127.0(M) RAIL FASTENING SYSTEMS

§127.1(M) Number Required

(a) Track shall be fastened by a combination of components which effectively maintains gage to the prescribed limits.

(b) Additional fasteners may be used where they are needed to hold gage and/or restrain the movement of rail (both longitudinal and lateral).

§127.2(M) Installation of Fasteners

§127.2.1(M) Elastic Fasteners/Clips

(a) All elastic fasteners shall be inserted or removed from the specially designed tie plate with an approved device such as an 8 lb. sledgehammer. ***The use of a spike maul is prohibited.***

(b) Elastic fasteners shall not be overdriven as overdriving will cause premature relaxation of the fastener.

Overdriven Pandrol E-Clip

Correctly Driven Pandrol E-Clip as End of Clip Lines Up with Edge of Tie Plate

(c) If a fastener has been overdriven or is not performing its intended function of limiting the vertical and longitudinal movement of the rail, it shall be replaced.

(d) In the case of an “e” clip, a distance of 3/8" (approximate width of a wooden pencil) between the shoulder and the face of the clip should be maintained. This clearance will prevent overdriving.

(e) When applying clips with a sledgehammer, the clip must be gently tapped to ensure proper insertion before the clip is fully seated. When removing clips with a sledgehammer, secure clip with foot and gently tap clip to remove the toe load to ensure safe removal of the clip.

(f) When installing clips, the tie must be tamped up flush with the base of the rail before driving the clip so as not to damage the clip. The clip is not to be used to pull the tie up to the base of the rail.

§127.2.2(M) Screw Spikes

(a) A 15/16" diameter lag screw shall be used to secure elastic fastener plates with 1" diameter holes to wood ties and timber. Lag screws must be screwed into a 11/16" diameter pre-drilled hole that is 6" deep. Driving of lag screws with a sledgehammer or spike maul is prohibited.

(b) As shown in the MBTA Standard Plan Book 1225, in turnouts, gage, slide, heel, frog and standard tie plates, all round holes will be filled with a screw spike except:

  (1) Self-aligning frog tie plates shall have one screw spike installed on each end of each plate.

(c) Holes for screw spikes shall be pre-drilled 11/16" in diameter and 6" deep.

§127.2.3(M) Cut Track Spikes

(a) All spikes (cut spikes) shall be driven with the head pointed toward the rail, except that spikes driven against the sides of insulated joints shall be driven with the head pointing away from the rail and not be in contact with the joint bars.

(b) Spikes should not be driven at ends of insulated joints as rail movement may cause the insulated joint bar to become electrically connected to the rail.

(c) Spikes must be started vertically and squarely and driven straight. The shank of rail holding spikes must have full bearing against the base of rail. Spikes should be driven

in accordance with the AREMA Manual, Chapter 5, leaving 1/8" clearance between the spike head and the base of the rail. Do not overdrive spikes.

(d) The use of lock spikes (hair pins) are prohibited. When existing lock spikes are removed they shall be replaced with cut spikes.

(e) Care must be taken not to strike the rail, its fastenings, or signal appliances when driving spikes.

(f) Spikes in main tracks, that have a cut throat, or are deteriorated due to rust, should be replaced.

(g) All old spikes, when pulled, shall be picked up and scrapped.

(h) Track spikes shall not be driven into round plate holes.

(i) When the head of the track spike is broken off, the replacement spike should be inserted in a new location, leaving the spike stub in the tie.

(j) All spike holes shall be plugged with cedar wood plugs, or with an approved plugging material, prior to re-spiking.

§127.3(M) Rail Fasteners Required

(a) Track shall be fastened by a system of components that effectively maintains gage within the limits prescribed.

(b) When spikes or elastic fasteners are used (unless otherwise ordered by the MassDOT Rail and Transit Division), each rail shall be fastened to every tie in the following manner:

Track **Conventional Tie Plates**	**Rail Holding Spikes**	**Plate Holding Spikes or Lag Screws**
Tangent and curves up to 1°	3 (1 field side rail holding; 2 gage side rail holding)	0
Curves between 1° and up to 4°	3 (1 field side rail holding; 2 gage side rail holding)	1 (1 field side)
Curves 4° and over and curved leads on all turnouts and crossovers	3 (1 field side rail holding; 2 gage side rail holding)	2 (1 field side; 1 gage side)[1]
Elastic Fastener Tie Plates	**Elastic Fasteners (Clips)**	**Lag Screws**
Tangent	2 clips	2 (1 field side; 1 gage side)[1] (2 cut spikes – 1 in each square hole field and gage)
All Curves	2 clips	4 (2 field side; 2 gage side) (2 cut spikes – 1 in each square hole field and gage)
All track with pre-plated ties	2 clips	4 (2 field side; 2 gage side)
Note: [1] Apply diagonally on opposite side of clip.		

§129.0(M) TRACK SHIMS

(a) If track does not meet the geometric limits (e.g., crosslevel or profile), track shims may be installed to temporarily correct the track surface.

(b) Shimmed track must be watched carefully to ensure that shims are in place and tight, and that proper gage and crosslevel is being maintained.

(c) If shims are used, they must be removed as soon as the weather, or other conditions, permit the track to be surfaced.

(d) Tie plates must not be removed from the ties as a means of adjusting the surface or crosslevel of track.

(e) Track shims must be at least the size of the tie plate and be spiked directly to the tie with spikes which penetrate the tie at least 4-1/2".

(f) Track shims must be bored where spikes are to be driven, and made of a material approved by MassDOT Rail and Transit Division.

(g) Track shims shall be braced if the shim is over 1" in thickness.

(h) Design and materials used in braces shall be approved by MassDOT Rail and Transit Division.

§145.0(M) BRIDGE GUARD RAILS

§145.1(M) Location

(a) A bridge guard rail is a continuous line of rails, connected by bolted joints or welds. The guard rail is fastened to the crossties or bridge ties adjacent to the gage side of the running rail.

  (1) One such rail is designated in these instructions as a “Single” bridge guard rail.

  (2) Two such continuous lines of rail, one adjacent to the gage side of each running rail is designated as a “Full” bridge guard rail.

(b) Guard rails are applied between the running rails of tracks at undergrade bridges which meet the below listed criteria. Full bridge guard rails shall be installed at the following locations:

  (1) Open deck bridges.

  (2) Ballast deck bridges.

  (3) Truss bridges (all).

  (4) Moveable bridges (all).

  (5) Other locations as directed by MassDOT Rail and Transit Division.

(c) Existing bridge guard rails applied in accordance to previous standards or practices need not be changed (unless instructed by MassDOT Rail and Transit Division).

(d) When it is necessary to remove bridge guard rail to perform work, bridge guard rail will be reinstalled only where required by the above instruction.

§145.2(M) Materials

(a) Suitable scrap or relay running rail may be used. The installed rail section will be approximately:

  (1) Level, but not more than 3/4" below the top of the adjacent running rails as per MBTA Standard Plan Nos. 3060 and 3062.

  (2) But in no case higher than the running rail.

(b) Install tie plates under guard rails on every other tie or timber. Tie plates should be installed with reverse cant.

(c) Joints shall be either four or six hole bars with a minimum of four bolts per joint. Joint bars shall not be used within the curved end section of the guard rail.

§145.3(M) Application

(a) Bridge guard rails shall extend a minimum distance of 39' (for speeds up to 60 MPH) and 78' (for speeds over 60 MPH), beyond each end of the bridge abutment, unless increased distances have been prescribed for specific territories or locations.

(b) The end of the bridge guard rails should be curved and brought to the center of the track.

(c) Guard rail ends shall have the rail ends beveled, bent down, or be fitted with a bridge guard rail nose. Each end shall be fastened to the center of the track so as to divert a derailed wheel and not catch dragging equipment.

(d) The guarding face of bridge guard rails on open deck bridges shall be parallel to and 12-5/8" from the gage of the running rail. If plates and clips are used on open deck bridges, see Paragraph (e) below.

(e) The distance of the guarding face will be changed in the following locations:

 (1) On ballasted deck bridges the guarding face shall be at 18".

 (2) On ballasted approaches to bridges the guarding face shall be at 18".

(f) Guard rail ends shall rest on a sound tie and be securely fastened.

§145.4(M) Inspection and Maintenance

Guard rails shall be inspected periodically to make certain that bolts and joints are tight, spikes are firmly against base of the rail, and castings fastened securely to rail ends, or ends properly beveled or bent down.

Subpart E - Tools

§150.0(M) TOOL REQUIREMENTS

(a) The person who is responsible for performing the track/switch inspection shall plan ahead and coordinate with the Operating Railroad Company to ensure that inspection tools are available when the inspection is made.

(b) The person who is responsible to perform track inspections shall notify the Operating Railroad Company when tools become in disrepair so that a tool can be fixed or replaced.

(c) Specified numerical limits given in this Part are to be confirmed during the track/switch inspection with the appropriate tool.

- (1) Values are not to be estimated or approximated.
- (2) Only values measured with approved tools are to be recorded on the Track Inspection Form.

(d) The person who is responsible for performing track inspections is encouraged to make periodic recommendations for improvements in existing tools or gauges and changes in tools that are needed to make the required inspection measurements.

§150.1(M) *Inspection Tools*

(a) Marking materials, as noted below, may be used to mark stations, tie lengths, dimensional data, and other information that will be made part of the inspection.

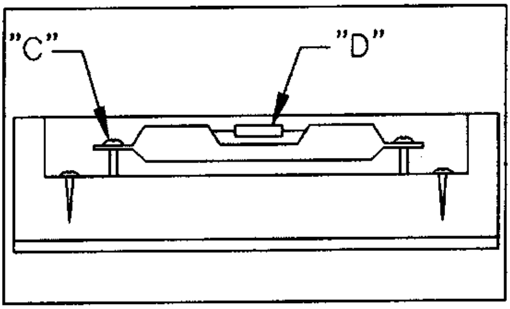
- (1) Crayon (keel);
- (2) Permanent metal marker.

(b) A mirror to be used to view difficult areas, especially the base or fillet of the rail, or connections to the moveable point frog and switch point area.

(c) A cloth measuring tape or folding wooden ruler may be used to measure track components and ties in the turnouts. The tape or ruler shall be non-conducting. The tape or folding wood ruler can also be used to measure switch point throw, frog guard face, and guard check, stations for alignment measurements, rail flow, tie spacings, offsets, and other key dimensional data.

(d) A standard combination track gauge with level shall be used so that gage, flangeway width, crosslevel, and superelevation measurements can be made.

- (1) Level Board:
  - (i) The person who is responsible for performing the track inspection shall ensure that the level board is checked and maintained to measure correct crosslevel readings.
- (2) Adjusting a Level Board:
  - (i) Set the level board on the tangent track where accuracy was checked and the difference in elevation between the two rails is known.
  - (ii) If required, turn the adjusting screw “C” to return the bubble “D” halfway between the readings for the known elevation. Center the bubble if possible.
    - Turning the adjusting screw to the right moves the bubble away from the screw (Memory Aid: “Turn screw right away”).
    - Turning the screw to the left moves the bubble toward the screw.



(iii) Turn the level board end for end and place it at the same point on the track.

(iv) See if the bubble is centered or the same. If the bubble rests at the same place, the board is adjusted.

(v) If the bubble readings are not the same, or not centered, continue steps (ii) through (iv). When the bubble is always at the same location (and centered), the level board is adjusted.

(3) Adjusting a level board by bubble positions:

(i) Place level board on the rails.

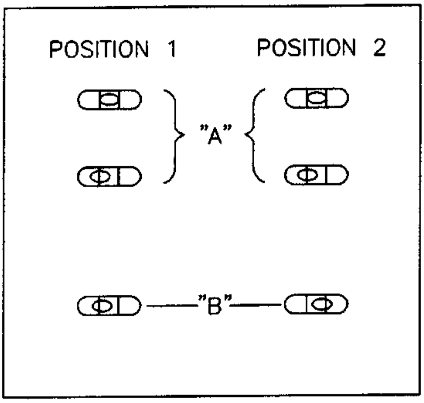
(ii) Note position of the bubble.

(iii) Turn level board end for end and place it at the same point on the track.

(iv) Note position of the bubble again.

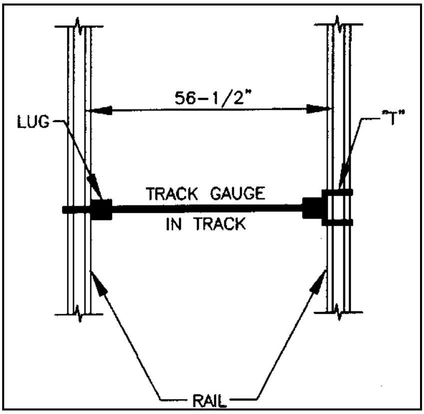
(v) If the bubble comes to rest in the same position both times “A”, the board is in adjustment.

(vi) If the bubble comes to rest in different positions “B”, adjustment of the board is necessary (see “Adjusting a Level Board” (d)(2)).



(4) The Track Inspector shall check and verify daily prior to use that standard track gauges are correctly measuring track gage.

(e) Checking a non-adjustable fixed track gauge.



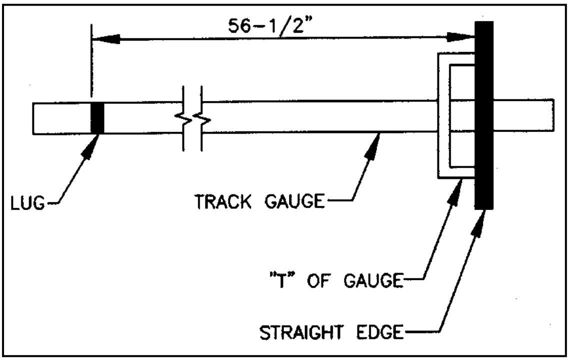
(1) Turn the gauge upside down.

(2) Place a straight edge along the “T” of gage.

(3) Measure the distance between the nearest face of straight edge and the lug.

  (i) If the measurement is 56-1/2", the track gage is accurate.

  (ii) If the measurement is not 56-1/2", the track gage is inaccurate. DESTROY AND DO NOT USE IT!



Track Gage Check

(f) A machined straight edge (minimum of 18" in length) shall be used to measure batter and chipping of rail ends, wear, flattened rails, mismatches (gage and tread) and engine burns on frogs and rail heads.

(g) A 36" machined straight edge with taper gauge shall be used to measure the straightness of field and plant welds.

(h) A taper gauge shall be used in conjunction with the straight edge to measure the depth of engine burns, flattened rails, and other anomalies in the rail head. In addition, the taper gauge shall be used to measure switch point/stock rail gap, and the gap at the moveable point frog.

(i) Stringline equipment capable of measuring 31' and 62' chords shall be used to check “alignment” spots. A discussion of stringlining curves is given in §55.2(M).

(j) Approved magnetic rail thermometer shall be:

(1) Calibrated in Fahrenheit, with a temperature range of 0°F - 150°F or as approved.

(2) Encased in housing with strong magnet(s) for attaching to web of rail.

(3) Meet AREMA Standard Rail Thermometer Plan 34-71, or approved equal.

(k) The following gauges may be used to check critical dimensions in and around frogs:

(1) Flangeway gauge: the gauge is designed to measure the flangeway in worn frogs so that grinding and welding repairs can be programmed. The gauge to be used by the Track Inspector shall conform to AREMA Plan No. 790-94.

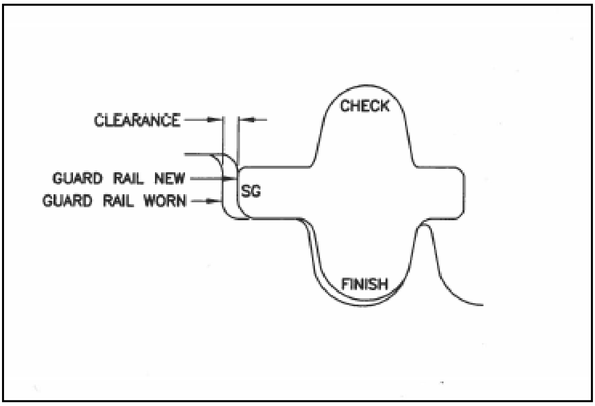
(2) Guard wear gauge: the gauge is designed to measure the wear on the guarding faces on a self-guarded frog.

(i) See AREMA plan for permissible variations in dimensions due to wear of frogs.

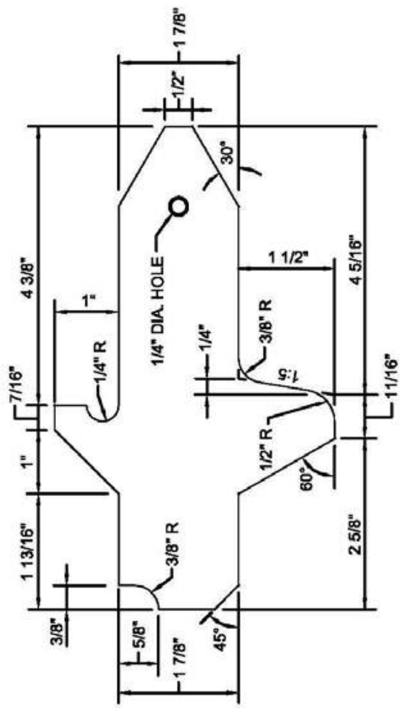
(3) The check gauge is used to test the flangeways in worn frogs and crossings for grinding or for welding repairs when necessary. It is designed for normal 1-7/8" flangeways and proper allowance should be made when used with wider flangeways. Standard contour gauge for self-guarded frogs is shown on the next page.

(4) The following check gauge graphic is used to measure flangeway widths in worn frogs and crossings to determine necessary welding and/or grinding repairs:

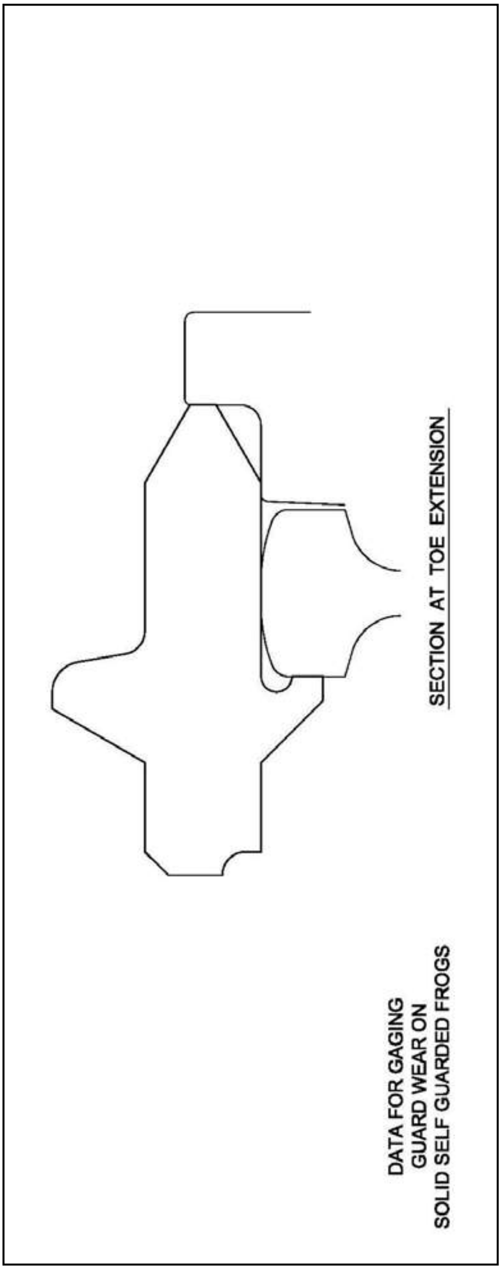
(i) The gage is designed for normal 1-7/8" flangeways.

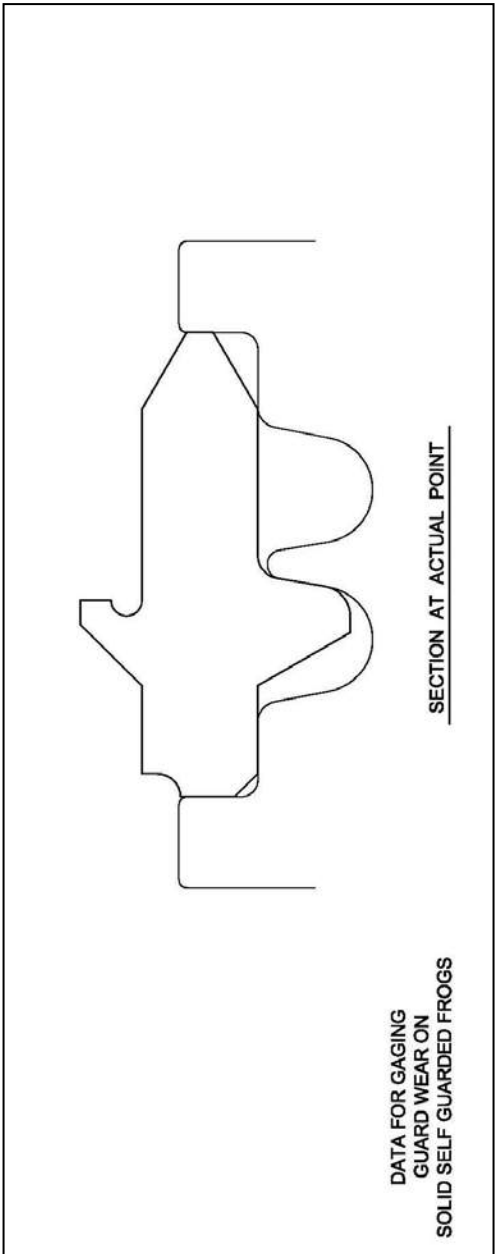


(5) The gauge to be used by the Track Inspector shall conform to AREMA Plan No. 790-02 as shown on the following pages.



DATA FOR GAGING
GUARD WEAR ON
SOLID SELF GUARDED FROGS


SECTION AT TOE EXTENSION
DATA FOR GAGING
GUARD WEAR ON
SOLID SELF GUARDED FROGS


SECTION AT ACTUAL POINT
DATA FOR GAGING
GUARD WEAR ON
SOLID SELF GUARDED FROGS

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SUBPARTS A-H

RECOMMENDED PRACTICE FOR THE MAINTENANCE OF SPECIAL TRACKWORK

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RECOMMENDED PRACTICE FOR THE MAINTENANCE OF SPECIAL TRACKWORK

TABLE OF CONTENTS

Subpart A – General

§1.0(STM) SCOPE

(a) This subpart will provide guidance as to the types of maintenance and maintenance limits required for special trackwork**.**

(b) This subpart shall be used by the MassDOT' s Operating Railroad Companies to maintain a safe, reliable track structure in the most economical and efficient manner possible.

(c) Forces engaged in the repair of special trackwork and appliances shall be aware that their maintenance goal is to provide a safe and reliable track structure with a superior ride quality.

(d) Ensuring adequate spare material inventory for all trackwork is the responsibility of the Operating Railroad Companies.

§2.0(STM) MAINTENANCE RESPONSIBILITIES

(a) MOW personnel in charge of making repairs and performing maintenance of turnouts and other trackwork shall attend and successfully complete courses prescribed by the Operating Railroad Companies.

(b) For Track Classes 1-5, individuals designated to supervise the maintenance, restoration, and renewal of trackwork shall be designated in accordance with FRA §213.7.

§3.0(STM) SCHEDULED MAINTENANCE ACTIVITIES

(a) Turnouts and other special trackwork must be maintained on a regular basis to:

  (1) Provide a safe and reliable track structure;

  (2) Provide acceptable ride quality;

  (3) Maximize the useful life of the special trackwork.

(b) The maintenance schedule for special trackwork is driven by:

  (1) Location of the special trackwork;

  (2) Frequency and accumulated tonnage over the special trackwork;

  (3) Type and maintenance history of the special trackwork;

  (4) Inspection reports of the Operating Railroad Companies.

(c) A summary of scheduled maintenance activities for special trackwork is given in the following table. This table is not intended to be all-inclusive and only identifies the major activities that are usually associated with special trackwork maintenance.

Scheduled Maintenance Activities for Special Trackwork

- Lubrication of switch and spring frog plates
- Maintenance grinding of frog, switch point, and stock rails
- Maintenance grinding of welds, forged areas, and slotting of mechanical joints
- Maintenance welding of worn frogs
- Maintenance welding of engine burns (≤3/8")
- Production grinding of special trackwork and approaches:*
  - 8-12 stone production switch grinder
- Inspection of gage, with attention to the spread of the rail due to defective fasteners, timber, and/or rail wear
  - Inspection of guard face gage, guard check gage and track gage
- Inspection of head block area (switch stand, timbers, and latches)*
  - Check the crank eye bolt under the switch stand to include cotter pin
  - Check the upright bolt and cotter pin at the connection between number 1 rod and the throw rod
  - Inspect all switch locks, circuit controller (CC) box, and unlock box for proper number and placement
  - Throw turnout to observe for loss of motion
  - Observe switch point and stock rail fit
- Maintenance, cleaning, and adjustment of switch targets
- Maintenance and replacement of gage plate and rod insulation*
- Spot tamping of trackwork*
- Out-of-face surfacing and alignment of trackwork*
- Spot replacement of major trackwork components (stock rails, switch points, frogs, etc.)*
- Spot rail replacement to include the replacement of insulated joints and curve worn rail*
- Bolt maintenance: tighten or replace loose and defective bolts and torque to specifications; inspect and install cotter pins as required
- Replacement or adjustment of defective fastener systems
- Maintenance of drainage and waterways
- Vegetation management
- Ballast maintenance
- Out-of-face ballast replacement (undercutting and shoulder ballast cleaning)*

***The Signal Department shall be notified prior to maintenance and inspection as noted above. In addition, the Signal Department must be notified when work is required on the following items:**

- Insulation on bridal plates
- Insulation on switch rods
- Repair/replacement of insulation joints
- Protection of track wires and bond wires

§4.0(STM) UNSCHEDULED MAINTENANCE ACTIVITIES

(a) Unscheduled maintenance activities are maintenance activities that cannot be planned or programmed.

(b) Unscheduled maintenance of special trackwork and components can be due to:

  (1) Any signal failure.

  (2) Natural events, such as fire, flood, severe storms, and extreme temperatures or extreme variations in temperature, and earthquakes.

  (3) A sudden change in the type of traffic, speed of traffic, or frequency of traffic over special trackwork.

  (4) A “run through” or derailment within the area of special trackwork or a component of special trackwork.

  (5) Failure of a component or components.

Subpart B – Maintenance Program

§5.0(STM) MAINTENANCE

Refer to §5.0(M)

§6.0(STM) PLANNING AND COORDINATION

(a) Refer to §3.0(STM) for the list of maintenance activities that shall be planned and performed by track forces.

(b) Programmed maintenance shall provide for the safety of train operations and shall be carried out in a cost-effective manner to provide maximum life to the trackwork and maximum benefit to the Operating Railroad Company.

(c) The information contained in inspection reports shall be used to plan trackwork maintenance.

(d) Program maintenance and/or capital maintenance and production should be internally coordinated with the Operating, Signal, and Bridge & Building (B&B) Department of the Operating Railroad Company.

(e) Planned maintenance that involves work within private rights-of-way (i.e., grade crossings and utilities), shall be coordinated with fire, police, public safety, and appropriate utilities (call 811 for Dig Safe). Also coordinate with local Department of Public Utilities (DPU) and/or State District.

§7.0(STM) QUALITY CONTROL

(a) The person in charge of performing the maintenance activity or repair shall be responsible for the overall quality of the work performed.

(b) All maintenance work shall be performed in accordance with these practices.

(c) An Operating Railroad Company Official shall periodically review the work performed for quality, consistency, and adherence to (b).

(d) Trackwork repairs that are deficient:

  (1) May be cause for remedial action.

  (2) Shall be brought to the attention of an Operating Railroad Company Official.

(e) An Operating Railroad Company Official shall see that any additional work necessary is performed to bring the repair into compliance with MassDOT recommended practice and shall re-inspect for substandard or deficient work.

(f) Operating Railroad Company personnel are encouraged to make recommendations as to the required modifications to methods, procedures, and practice to improve the overall quality of work.

Subpart C – Scheduled Site Maintenance Activities

§33.0(STM) DRAINAGE AND WATERWAYS

Drainage in and around special trackwork shall be maintained in accordance with §33.0(M).

§37.0(STM) VEGETATION MANAGEMENT

Vegetation in and around special trackwork shall be maintained in accordance with §37.0(M).

Subpart D – Maintenance Limits

§50.0(STM) SCOPE

(a) Maintenance is the repair or replacement of a component of special trackwork which may include switch points, frogs, and fastenings.

(b) Maintenance limits are to be used as a triggering mechanism that prompts maintenance or reconstruction.

(1) It is MassDOT's goal to have special trackwork that is maintained above FRA minimum standards.

(2) As special trackwork components wear, maintenance should be programmed before the track reaches the maintenance limits.

(3) Maintenance must be executed whenever the maintenance limits are exceeded and completed prior to reaching the FRA minimum standards.

(4) Whenever possible, special trackwork should be repaired or reconstructed to as-new condition.

(c) The maintenance limits and recommended practice for special trackwork and other trackwork are found in this subpart or the applicable maintenance sections.

§53.0(STM) GAGE

Refer to §53.0(M), "Gage."

§55.0(STM) ALIGNMENT

(a) Maintenance shall be performed when alignment values reach the limits given in §55.0(M) Alignment.

(b) The straight stock rail (open point) in a turnout is the line rail. If stations fall within undercut portions of the stock rail, alignment measurements may be taken on the field side of the stock rail.

(c) In special trackwork, alignment deviation in curves is the difference in the mid-ordinate value between adjacent stations and not the average of multiple stations (uniformity) as given in FRA §213.55.

§63.0(STM) TRACK SURFACE

(a) The following criteria:

(1) Will serve as a practical guide for the maintenance of smooth riding conditions in special trackwork; and

(2) Will minimize the wear on special trackwork, special trackwork components, and rail vehicles.

(b) For Track Classes 1-5, surface may not deviate more than the amount prescribed in the table in §63.2(M).

Subpart E – General Maintenance Requirements

§133.0(STM) TURNOUTS AND CROSSOVERS

§133.1(STM) Use of Turnouts and Crossovers

(a) Turnouts and crossovers are designated by their frog numbers and should be used as follows:

(1) No. 20: At interlocking plants for crossing over of high speed trains from one main track to another main track (normally used in the same or reverse direction in locations where the normal speed is 50 MPH or more).

(2) No. 15: At interlocking plants for movements to another main track (normally used in the same or reverse direction, where conditions do not justify or afford the distance required for No. 20 frogs). For diverting trains to sidings or other tracks and returning trains to main tracks through power operated or spring switches.

(3) No. 10: For all other turnouts from main tracks and sidings, where practicable, and in yards and terminals.

(4) The use of other turnouts must have the approval of MassDOT Rail and Transit Division.

§133.2(STM) Speeds Through Turnouts

(a) The maximum permissible speeds through turnouts when located in tangent track will be as follows:

Frog No.	Switch Point/ Switch Rail Length (Ft.)	Maximum Authorized Speeds (MAS) (MPH)
20	59'-6"	60*
20	39'	45
20	39'	60*
15	38'	30
15	26'	30
10	27'	15
10	16'-6"	15
8	16'-6"	10
Note: * With equilateral turnouts only.		

(b) When turnouts or crossovers are located in curved tracks, speed must be adjusted in accordance with FRA §213.57.

(c) The maximum authorized speed (MAS) through turnouts shall be designated by the MassDOT Rail and Transit Division.

§135.0(STM) SWITCHES

(a) Switch points and moveable points should be kept in line and surface with all bolts tight and cotter pins in place.

(b) Switch points must fit the stock rails closely and accurately, with a full bearing against the head of the stock rail. If a wear pattern indicates bearing only along the top edge of point, the cause of wear shall be investigated and corrected.

(c) When an open switch point is found of more than 3/16", it must be immediately corrected and/or removed from service.

(d) Each switch stand in connecting rod must be securely fastened and operable without excessive loss of motion.

  (1) Connecting rod bolts must be of the proper size and installed with the bolt facing upwards and the nut on top.

  (2) The upright bolt and nut shall be drilled to accept and installed with a cotter pin.

(e) Switch points and stock rails should have the overflow ground off. Attention should be given to the overflow and fit of the back side of the switch point to the stock rail.

(f) When necessary to replace individual switch points or stock rails, use replacement material of similar kind (i.e., Samson points to Samson stock rails; plain points to plain stock rails).

(g) When replacing or changing a switch point, replace switch points and stock rails as a set:

  (1) Fastenings must be intact and maintained so as to keep the components securely in place.

  (2) Also, each switch, frog, and guard rail must be kept free of obstructions that may interfere with the passage of wheels.

  (3) Classes 3-5 track must be fully box anchored through and on each side of track crossings and turnouts to restrain rail movement affecting the position of switch points and frogs. Elastic fasteners designed to restrict longitudinal rail movement are considered the same as rail anchors.

(h) Adequately fasten switch points and stock rails to prevent lateral and longitudinal rail movement.

(i) Upright bolts used with horizontal switch rods must be placed with nut ends up and nuts secured with cotter pins so they can be visually inspected.

(j) Switch points shall be replaced when worn or chipped so that the top of the switch point, at any place, is more than 7/8" below the plane across the top of the stock rails.

(k) Unusually chipped or worn switch points that are found to have an unprotected flat, vertical service, 5/16" or more in width, at a depth of 3/4" below the top of the stock rail and switch point, must be removed from service and replaced immediately. This type of point wear may contribute to a wheel climb derailment.

(l) Switch points shall be replaced when the raised portion of the switch point (rise) is worn down to the level of the top of the stock rail. The purpose of the rise is to prevent the outer edge of the wheel tread from striking the stock rail and rolling the stock rail out of the switch plates and causing a derailment.

(m) Chipping or wear on any switch point should be investigated, its cause determined and corrective action taken. Wear or chipping produces a sloping surface on the face of the switch point which may tend to lift a wheel having an imperfect flange. The switch rail should be further examined to locate any point of hard contact by the wheel, which might contribute to wheel climb.

(n) Spot grinding of points is allowed to remove chips, minor burns, small imperfections, small cracks, etc., with care being taken to insure that proper profile is restored to the switch point to prevent wheel climb. Grinding is not to exceed 7/8" below top of stock rail.

(o) When changing switch points and curved closure rails, or when grinding switch points, lubricate as follows:

   (1) The gage face of the curved point and the curved closure rail.

   (2) Spot lubricate top of straight closure rail in vicinity of switch point.

   (3) Lubricate gage face of all ground switch points.

(p) Switch points, components, and connections must be examined frequently.

   (1) It is important that the stock rails are securely seated and have no movement in the switch plates.

   (2) Care should be taken to avoid canting the rail by over-tightening the rail braces.

   (3) Switch plates shall have no movement on the ties.

(q) Switch plates and moveable parts should be kept clean and lubricated with an approved graphite dry lubricant.

(r) The heel of each switch point must be secured and the bolts of each heel must be kept tight (e.g., fixed blocks).

(s) In yards when using No. 10 turnouts or smaller, and the maximum authorized speed does not exceed 15 MPH, a switch point guard may be applied to the outside of the stock rail.

(t) Switch point guards shall be used only in yards and installed so that the distance of the guarding face of the guard to the gage face of the switch point is set at 3-15/16". The gage face of the switch point guard shall be restored by welding once the wear exceeds 1/4" (4-3/16").

§137.0(STM) FROGS

(a) See AREMA Standard Track Plan No. 300 for guidance on the use of frogs.

(b) All metal flow from frogs must be ground promptly and the gage and guard edges of castings rounded. The radius shall be ground to match the original radius and contour of the frog. See AREMA Standard Track Plans or manufacturer’s shop drawing.

(c) New frogs should be ground 30 days following installation. Subsequent grinding will be required monthly for the first several months depending on frog type and service.

(d) Frog points, frog castings, and wheel relief areas (false flange), should be built up by welding to maintain as-new cross section. Spring rail frogs also have false flange relief areas by design. See AREMA Standard Track Plans or manufacturer’s shop drawing.

(e) Worn frogs should be repaired in track by an approved electric welding method and then ground to the correct contour.

(f) Each flangeway in special trackwork must be at least 1-1/2" wide with a 1/8" head radius.

(g) The flangeway depth, measured from a plane across the wheel-bearing area of the frog, may not be less than 1-3/8" in Track Class 1 or less than 1-1/2" in Track Classes 2-5.

(h) If a frog point is chipped, broken, or worn more than 1/2" down and 3" back, the frog should be repaired.

(i) If a frog point is chipped, broken, or worn more than 5/8" down and 6" back, operating speed over that frog may not be more than 10 MPH.

(j) If a riser or insert of a frog is broken out or worn down more than 3/8" below the original contour, operating speed over that frog may not be more than 10 MPH.

(k) Welding repairs on manganese (Mn) steel frogs shall be performed by a welder certified to weld manganese steel.

(l) All frog repairs should be ground to contour. Square corners lead to breakouts into the flangeway.

(m) Frog welding may be prolonged indefinitely by proper grinding practices.

(n) Missing or loose frog bolts shall be retightened or replaced with bolts of correct length and diameter.

(o) All frogs requiring repairs that cannot be made in track shall be removed from track and shipped to the designated repair point.

(p) Frogs shall be supported on effective timber that is fully tamped to minimize wear and damage from train traffic.

§139.0(STM) SPRING RAIL FROGS

(a) Spring frogs have a moveable wing rail that is normally held closed against the body of the frog except when pushed open by a diverging movement. This results in a smoother ride for main line moves.

(b) Spring frogs must be inspected to comply with FRA §213.139.

(c) Recommended practice for the proper installation, inspection, and maintenance:

  (1) Spring frogs must be inspected on foot at least once per week.

  (2) Good surface, line, drainage, and timber condition must be maintained.

  (3) The outer edge of a wheel tread must not be permitted to contact the gage side of the spring wing rail.

  (4) All bolts should be tight:

    (i) Some body bolts are special thin head bolts.

    (ii) Maintenance body bolts (studs) are available for locations where frog must be disassembled to install new bolt.

  (5) Ensure spring wing can move freely.

(d) Spring rail frogs are to be used on industrial tracks that are used infrequently (unless approved by the MassDOT Rail and Transit Division).

(e) The clearance between the hold-down housing and the horn may not be more than 1/8" at the top and 1/8" at the bottom. Other issues to be addressed:

  (1) Wing and point must fit properly. Grind overflow to prevent chipping. Grind gage corner radius to 5/8".

  (2) The spring wing to frog point is designed to have a 3/8" gap at the point. A gap of no more than 3/4" must be maintained.

  (3) Ensure there is sufficient tension on spring:

    (i) The spring nuts should be adjusted to compress the spring 1" (1/4" between spring follower and housing).

    (ii) This results in approximately 600 pounds of force from the spring.

(f) Typically, by design, there is a gap of up to 3/8" between the spring wing rail and frog point within the first 5" of the frog point. It is desirable to maintain contact between the spring wing rail and the remainder of the frog.

  (1) A gap less than 3/4" is to be maintained.

(2) If a gap of 3/4" exists, check the compression of the springs on the wing rail to see if the springs must be adjusted and/or replaced.

(g) Particular attention should be paid to the guard face gage in the point area on the straight side of the turnout. A guard rail protects the straight move through the length of the moveable wing.

(h) The outer edge of a wheel tread must not contact the gage side of a spring wing rail.

(i) When surfacing a spring frog:

(1) Do not jack the frog with production equipment between the toe and heel. This could bend the base plate.

(2) Use hydraulic hand jacks.

(j) Base plate and horns should be lubricated with switch plate lubricant.

(k) The toe of each wing rail must be solidly tamped and fully bolted, or preferably, field welded.

(l) Spring frogs should be ground 30 days after installation. Subsequent grinding may be required monthly for the first several months depending on frog type and service.

(m) Welding of a spring rail frog may only be performed with the permission of the MassDOT Rail and Transit Division.

(1) If a spring rail frog is welded in the field, the first train will operate at Class 1 speeds, freight trains at 10 MPH, and passenger trains at 15 MPH.

(2) The spring rail frog will be re-inspected after the first train before the track will be returned to MAS.

(n) Each spring must have sufficient compression force to hold the spring wing rail against the point rail.

(o) Lubricate spring frog plates with approved lubricant in the Spring, Summer and Fall and “Ice Free Switch” anti-icing agent in the winter (or approved equal).

(p) The opening between the spring wing rail and frog point of spring frog shall be kept free of any debris and snow and ice that may impede the operation of the spring wing rail.

§141.0(STM) SELF-GUARDED FROGS

(a) Self-guarded frogs shall be used in non-main tracks where the speed does not exceed 15 MPH.

(b) If, because of wear, repairs need to be made to the guarding face of a self-guarded frog:

(1) The raised guard face of a self-guarded frog may not be worn horizontally more than 3/8".

(2) Repairs require the use of a contour gauge (see §150.1(M), “Inspection Tools”).

(3) The track should be taken out of service.

(4) When repairing the guard face of a self-guarded frog, the build-up of weld material must be made from the top down to prevent wheel climb

(5) When repairs are made to a self-guarded frog, the guard face must be restored before rebuilding the point. This practice will ensure that the wheel does not strike the rebuilt frog point.

§142.0(STM) GUARD RAILS

§142.1(STM) Guard Rails - General

Guard rails shall be furnished in accordance with MBTA Standard Plan Book, AREMA Standard Plan Book, or as approved by the MassDOT Rail and Transit Division.

§142.2(STM) Guard Rails - Use

(a) Guard rails used with No. 15 spring frogs shall be a minimum of 16'-0" in length. Guard rails used with frogs of lesser number shall be a minimum of 13'-0" in length.

(b) Guard rails used with No. 10 spring frogs shall be a minimum of 16'-0" in length, or as approved by the MassDOT Rail and Transit Division.

(c) Guard rails installed in accordance with previous standard practice may be continued in general use until their replacement becomes necessary.

(d) Relay quality hook flange guard rails must only be reinstalled in other than main tracks.

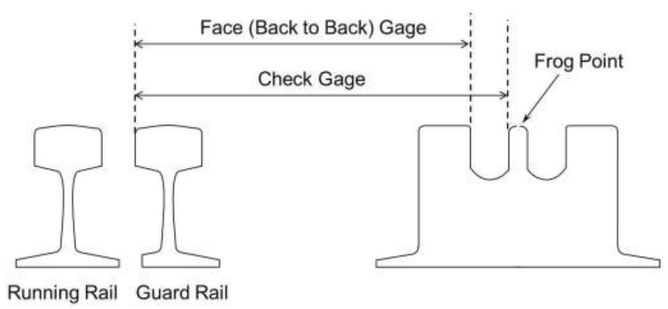
§143.0(STM) FROG GUARD RAIL AND GUARD FACES; GAGE

(a) If possible, when performing trackwork maintenance, repairs shall be made to restore the installation dimensions of guard rails:

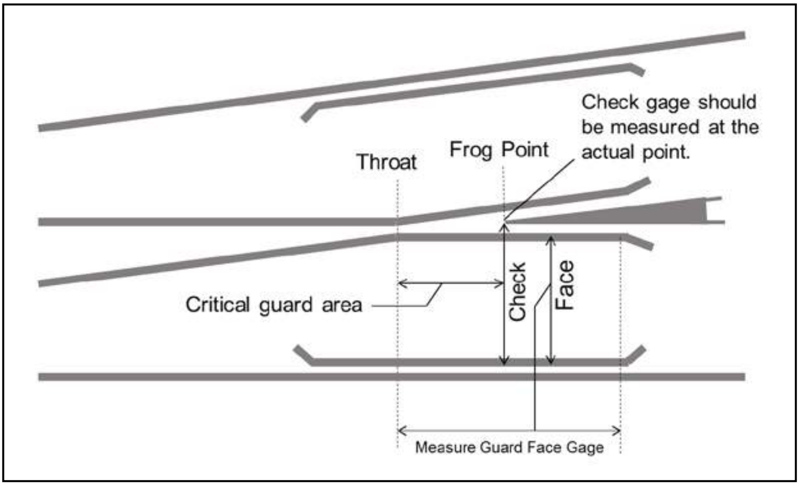
Track gage	56-1/2"
Guard check gage (may not be less than)	54-5/8"
Guard face gage (back to back) (may not be more than)	52-3/4"

(b) Maintenance limits contained in Paragraph (a) are more restrictive than those found in FRA §213.143.

(c) See the following diagrams showing guard check gage and guard face measurement locations.



Guard Check and Guard Face Gage



Guard Check and Guard Face Gage Measurement Locations

§144.0(STM) INSTALLATION OF SPECIAL TRACKWORK GUIDELINES

(a) Trackwork constructed in track, or at the site, shall be built to, and perform to the MBTA Standard Track Plans, AREMA Standard Track Plans, or as approved by the MassDOT Railroad Transit Division.

(b) Turnouts and crossovers shall not be placed in curves or spirals without the approval of the MassDOT Rail and Transit Division.

(c) Pre-plated, pre-assembled switch timber and pre-fabricated switch nose panels (if truckable), are preferred.

(d) Care must be used in unloading and handling all trackwork, timber, and turnouts. This includes handling and unloading from flatbed cars and trucks and assembling and loading onto transport cars.

(e) A minimum 12" bed of clean-bottom compacted ballast shall be provided with good drainage. See MBTA Standard Plan Nos. 1000 and 1002.

   (1) If roadbed materials (sub-ballast and sub-grade) are inadequate, an 8" layer of compacted sub-ballast shall be installed; or

   (2) A 5" layer of compacted hot-mix asphalt under-layment as per MBTA Standard Plan No. 1030; or

   (3) A Geo-Web (or approved equal) sized appropriately for the field conditions (4", 6", or 8") may be used as determined by the MassDOT Rail and Transit Division.

(f) When practicable, special trackwork should be completely installed with switches connected to their operating mechanisms and properly adjusted before trains are permitted to move over the trackwork.

(g) Care must be used when installing trackwork panels to prevent rail bending, tie splitting, or tie cracking, as well as bending and/or breaking fasteners and OTM.

(h) When installing special trackwork panels, bottom ballast should be furnished and installed and compacted level to within 2" to 4" of final bottom of tie grade. The final lift shall be nominal 1-1/2". (Ballast bagging or blocking can be used when undercutting or in emergencies.)

(i) Initial surfacing lifts for special trackwork shall be limited to 2" increments. This size lift helps prevent tie breakage, and the bending of rail and plates in spring and moveable point frogs. The final lift shall be a nominal 1-1/2".

(j) Where only one switch rail (closed point) has been installed in a main track turnout in existing main track, and it is necessary to move trains over the turnout, the following precautions must be taken:

  (1) All switch plates on the turnout side must be in the correct position and clipped and/or fully fastened.

  (2) The switch rail must be securely held against its stock rail by driving a spike in each of the first two ties back of the point and, where possible, spikes must pass through holes in the switch plates.

  (3) The switch point must be secured to the stock rail by standard clamping devices.

  (4) Unconnected ends of lead rails, or the toe of the frog, must be protected by a tapered wedge fastened to the tie to protect against dragging equipment.

  (5) The free end of stock rail must be fastened down to prevent movement and a tapered wedge fastened to prevent against dragging equipment.

  (6) Facing point train movements shall only be made under a 10 MPH temporary speed restriction unless point detection is provided.

(k) If both switch rails have been installed, but not properly connected to the switch operating mechanism, the following must be done before trains are permitted to move over the main track turnout:

  (1) Switch rods must be installed.

  (2) The main track switch rail must be secured against its stock rail, as required above.

  (3) The diverting switch rail (open point) must be blocked by driving a wooden wedge, not less than 18" long, between the switch rail and the stock rail.

  (4) On wood ties, a wedge must be secured in place by means of a lag screw or heavy nail through one clip bolt hole and a piece of wood placed against the end of the wedge and spiked to the first and second ties ahead of the point.

  (5) Unless the curved lead has been installed and spiked or clipped to prevent movement, a connecting rail shall be fastened to the heel of the open switch rail and moved away from the running rail so as to provide at least 5" clearance between rail heads.

  (6) Facing point train movements shall only be made under a 10 MPH temporary speed restriction unless point detection is provided.

(l) The main track guard rail must be correctly placed and clipped or spiked if the frog has been installed.

(m) Unconnected ends of lead rails or the toe of the frog must be protected by a riser wedge fastened to the tie to protect against dragging equipment.

(n) Where track is signaled, a switch circuit controller shall be installed, tested and functioning, by a signal employee of the Operating Railroad Company.

Subpart F – Scheduled Maintenance Activities

§150.0(STM) DESCRIPTION OF SCHEDULED MAINTENANCE ACTIVITIES TO BE PERFORMED

Refer to the table in §3.0(STM) for the list of major trackwork activities to be performed by the Operating Railroad Company.

§151.0(STM) RECORD OF TRACKWORK DISTURBANCE IN CWR TERRITORY

(a) Maintenance activities performed in trackwork installed in CWR track can cause a change in the rail neutral temperature (RNT) of the CWR and cause track instability in and around the special trackwork.

(b) MOW employees in charge of, or responsible for maintenance work performed in and around special trackwork in CWR track, shall be thoroughly familiar with and understand and comply with Appendix A, "Continuous Welded Rail (CWR) Procedures."

§152.0(STM) LUBRICATION OF SWITCHES AND FROGS

(a) Switch and spring frog plates shall be cleaned and lubricated as necessary.

(b) The Signal Maintainer has the overall responsibility to lubricate powered switches and derails in signaled track.

(c) The Track Department has the responsibility to lubricate all other switches, derails, and spring frogs with approved seasonal lubricants.

§152.1(STM) Lubrication of New Switch Points

(a) New switch points shall be greased after installation.

  (1) Special attention should be paid to lubricate the gage face of the diverging point from point of switch to point of frog.

(b) Existing switch points that show indication of wear should be carefully lubricated frequently on the gage face so as to prevent migration to the top of rail, as well as excessive ground and ballast contamination.

§156.0(STM) SURFACING (SPOT TAMPING) - GENERAL

(a) Spot tamping (less than 200') is required to restore the surface and line when deviations approach the alignment and surface maintenance limits given in §§55.0(M) and 63.0(M).

(b) Spot tamping is required to eliminate the excessive deflection and pumping of ties which:

  (1) Overstresses clips causing premature failure or backing out of clips.

  (2) Increases abrasion of the wood ties.

  (3) Fouls the ballast.

  (4) Increases ballast abrasion and wear.

  (5) Changes the load distribution over the length of the tie which, in some cases, may overstress the tie.

(c) Tamping should be performed in such a manner as to prevent the centerbinding of timber and ties.

(d) In wood tie turnouts, head block and movement ties may require tamping by hand to provide full support of the long timber.

(e) When spot surfacing in welded rail territory, see Appendix A, "Continuous Welded Rail (CWR) Procedures."

§157.0(STM) OUT-OF-FACE SURFACING AND ALIGNMENT

(a) Out-of-face surfacing (greater than 200') shall be accomplished by multiple tool switch tampers, ballast stabilizers, and ballast regulators.

(b) Out-of-face surfacing is usually required when there are multiple spots to be surfaced that are greater than 200' in length.

(c) Out-of-face surfacing is required to restore the overall surface and line when deviations approach the alignment and surface maintenance limits given in §§55.0(M) and 63.0(M).

(d) The Operating Railroad Company shall plan any out-of-face surfacing program for trackwork. The Operating Railroad Company MOW personnel shall make use of information on the Track Inspection Report, Special Track Inspection Report, Monthly Switch Inspection Report, track geometry car readings (if available) and train rides when planning the out-of-face surfacing program.

(e) Out-of-face surfacing and aligning of CWR track should be avoided:

- (1) When the ambient air temperature is 80°F, or rail temperature is 100°F, or above;
- (2) Anytime there is an ambient air temperature of 40°F, or below, for a 24-hour period. To surface and align track below the above temperature requires the approval of MassDOT Rail and Transit Division.
- (3) Any other time when questionable track conditions exist that will not safely support surface and alignment of track.

(f) When out-of-face surfacing in welded rail territory, see Appendix A, "Continuous Welded Rail (CWR) Procedures."

§158.0(STM) SPOT REPLACEMENT OF MAJOR COMPONENTS

(a) During the useful life of special trackwork, it may be required to replace major components and systems as part of a programmed maintenance activity. The major components include, but are not limited to:

- (1) Switch points, stock rails, and/or point protectors.
- (2) Switch plates or tie plates and clips and fasteners.
- (3) Frogs and guard rails.
- (4) Bolt assemblies.
- (5) Closure rails (associated joint and insulated joints).
- (6) Switch timber and headblock ties.
- (7) Switch stands, switch machines, and/or derails.
- (8) Switch targets, handles, rods, and cotter pins.

(b) The replacement of major components is based on:

- (1) The physical condition of the component.
- (2) The amount of measured wear on the component compared to an established maximum "wear limit" as given in this Part.
- (3) The ability of the component to sustain MAS and meet the operational requirements of the railroad.
- (4) Lost motion of any moving switch parts.

(c) When changing major components, all work performed shall be reported on the daily Track Inspection Report and be available to the MassDOT Rail and Transit for review.

§159.0(STM) SPOT RAIL REPLACEMENT

(a) Rail replacement shall be performed on an as-needed basis as traffic and local conditions warrant.

(b) The replacement of rail is based on:

  (1) The age and physical condition of the rail.

  (2) The existence of a rail defect as defined in FRA §213.113.

  (3) The amount of measured wear on the rail compared to an established "wear limit" for that rail as given in §113.2(M).

  (4) Switch point to stock rail wear limits as given in this Part take precedence over the maintenance limits given in §113.2(M).

(c) A "Rail Failure in Main Track Report" must be filled out and available for MassDOT Rail and Transit Division to review every time a rail is changed.

§160.0(STM) BOLTS AND LOCK WASHERS

(a) During the useful life of trackwork there may be a requirement to replace broken or defective bolts and/or washers in frogs, heel blocks, and at permanently bolted joints.

(b) When evaluating the performance of bolts:

  (1) Verify that the bolt is of the correct diameter, length, and type.

  (2) Visually inspect the performance of the bolt and washer under load.

  (3) Visually inspect the joint or appliance and look for signs of vertical movement, batter, crushing, excessive flow, or excessive wear in the component affixed with the bolt and washer.

  (4) Visually inspect the condition of crib ballast and general line and surface at that location.

  (5) Visually inspect the condition of ties, plates, and clips at bolted locations.

(c) When changing a bolt in a joint, frog, or in a switch point, tighten all other bolts in the immediate vicinity.

(d) The preferred method of tightening new bolts is with a torque wrench and multiplier that applies the recommended level of torque (foot-pounds) to the bolt. See the following tables.

Recommended Torque Values in ft.-lb. to Produce the Minimum Specified Tension in Society for Automotive Engineers (SAE) Grade 5 Bolts

Bolt Diameter	Min Tension (lb.)	Lubricated Condition(1)	Non-Lubricated Condition(1)
1/2"	12,000	80	105
5/8"	18,000	155	210
3/4"	28,000	275	370
7/8"	39,000	450	600
1"	51,000	670	800
1-1/8"	56,000	825	1,100
1-1/4"	71,000	1,165	1,550
1-3/8"	85,000	1,535	2,040

Note:

(1) Lubricated torque valves shall be achieved by applying a metal-based lubricant to the bolt threads.

Recommended Torque Values in ft.-lb. to Produce the Minimum Specified Tension in SAE Grade 8 Bolts

Bolt Diameter	Min Tension (lb.)	Lubricated Condition[(1)]	Non-Lubricated Condition[(1)]
1/2"	15,000	100	130
5/8"	24,000	195	265
3/4"	35,000	345	460
7/8"	49,000	565	750
1"	64,000	840	1,120
1-1/8"	80,000	1,180	1,575
1-1/4"	102,000	1,675	2,230
1-3/8"	121,000	2,185	2,910

Note:
(1) Lubricated torque valves shall be achieved by applying a metal-based lubricant to the bolt threads.

§161.0(STM) FASTENING SYSTEMS

(a) During the useful life of trackwork, it may be required to change rail fasteners (e.g., clips or spikes or screw spikes) as a normal maintenance activity.

(b) The replacement of fasteners is based on:

(1) The physical condition of the fastener (worn or corroded and/or broken or missing).

(2) The ability of the fastener and the fastening system to minimize the horizontal and vertical movement, as well as the longitudinal movement of the rail or components (e.g., switch points, frogs and guard rail), and to sustain maximum authorized speed.

(c) When evaluating the performance of fasteners, the Foreman shall:

(1) Verify that the correct type of fastener is being used.

(2) Visually inspect the fastener for cracks and breaks.

(3) Visually inspect the fastener to see if they are overdriven.

(4) Visually inspect the components being fastened and look for signs of vertical or horizontal movement or excessive wear.

(d) Clips that have repeatedly backed-out or fallen-out should be replaced with new clips and not reused.

Subpart G – Turnouts in Signalized Track

§170.0(STM) GENERAL PROCEDURES FOR WORK ON TURNOUTS IN SIGNALED TERRITORY

(a) When adjusting or working on a main track turnout in signaled territory:

(1) Notify the Signal Maintainer.

(2) Obtain foul time, track time or other form of Roadway Worker Protection (RWP) from the dispatcher.

(3) Hold a job briefing.

(4) Block the switch point.

(5) Perform the work.

(6) Remove blocking.

(7) Perform obstruction test (by Signal Maintainer).

(8) Make sure hand-thrown turnout is aligned and locked with an approved lock in the normal position before returning to service.

(9) Return track to service.

Subpart H – Mechanisms, Appliances, and Devices

§200.0(STM) SWITCH OPERATING MECHANISMS

§200.1(STM) Use of Mechanisms

(a) Switches shall be operated by approved types of mechanisms as follows:

(1) Power mechanisms as approved by the MassDOT Rail and Transit Divisio**n** after recommendation by the Signal Department.

(2) Spring switches: Manually operated switch mechanisms, which are supplemented by slow-acting spring devices that permit wheels to trail through switches set for the opposite route, may be used with the approval of the MassDOT Rail and Transit Division.

(3) Approved type of new installation switch stands (unless approved by MassDOT Rail and Transit Division), are: Racor Model 36EH (High Mast) for mainlines and Racor Model 36E for yards.

(4) Manual operated mechanisms shall use the “back saver” and/or “triangular hand level” handles for new installations.

§200.2(STM) Installation of Switch Stands

(a) Manually operated switch stands shall be placed so that the operating rod is in tension when the switch is set in normal position.

(b) Whenever possible, the switch stand handle shall be positioned facing the frog when the switch is in the normal position.

(c) Where crossover switches are protected by signals, a switch locking arrangement shall be provided.

(d) Switch stands for all tracks shall be located to serve the safety and efficiency of employees.

§205.0(STM) SWITCH POINT POSITION INDICATORS (TARGETS)

§205.1(STM) General

(a) Where required, indicators shall be provided on all non-interlocked switches to give a clear and distinct indication of the position of the switch points

(b) Switch point targets shall be reflectorized. The height of the centerline of the target shall not exceed 20" above the track ties. Targets higher than this are called “high targets.”

(c) Generally, high targets with the EH36 high stand are used on all main track.

(d) Generally, low targets are used in yards and at locations on main tracks where clearance precludes the use of a high stand.

§205.2(STM) Installation of Position Indicators

Targets shall be set at right angles to the track and perpendicular to the headblock ties.

§205.3(STM) Maintenance

Switch targets should be kept clean to provide uniform brightness and visibility.

§205.4(STM) Position Indication

(a) In order to give a clear and distinct indication of the position of non-interlocked switch points, colored targets shall be provided, in addition to the switch stands.

(b) Target colors are given in the Northeast Operating Rule Advisory Committee (NORAC) Rule Book (Rule 104H).

(1) Where switch targets are used, a green or white banner indicates normal position of the switch, and a red or yellow banner indicates reverse position.

(2) Green and white banners are used on main tracks, and red and yellow banners are used on other than main tracks and yards.

§205.5(STM) Distance from Rail for Switch Stands and Switch Point Targets

(a) Switch stands, not between tracks, must be placed so that the distance from the gage of the nearest rail to the center of the spindle with a low mast is 4'-1" and with a high mast is 7'-0".

(b) Low target masts placed between tracks must be installed as follows:

Track Center Distance (at least)	**Minimum Distance From Gage of Nearest Rail to Center of Spindle**
12'-2" but less than 13'	3'-8-3/4"
13' or greater	4'-1

(c) All powered switch machines shall be installed as per Signal Department Instructions.

§210.0(STM) SWITCH STAND MAINTENANCE

(a) Switches, switch stands, and operating rods must be examined frequently. Broken, damaged, or missing parts shall be replaced immediately.

(b) Regular inspection shall be in accordance with FRA §213.233, and if necessary, corrective action must be taken immediately.

(c) Worn switch latches must be replaced before the wear is sufficient to permit the switch lever to be thrown without manually releasing the latch (keeper).

(d) Special attention should be taken to ensure that the cotter pin is maintained at the clevis location at the base of the switch stand and at the connection to the No. 1 rod (FRA §213.135).

§220.0(STM) SWITCH LOCKS

(a) At all main track switches, throw levers of switch stands, shall be secured by two latches (for normal and reverse positions), and locked by a standard switch lock. The lock is to be fastened by a chain to the switch stand, or tie, so that the switch can only be locked in the normal position.

(b) The throw levers of switch stands in other than main or secondary track, shall be provided with latches, but shall be provided with padlocks only when required.

(c) The standard switch lock used by the Operating Railroad Company is to be approved by MassDOT Rail and Transit Division.

(d) Recommended operating and cleaning procedures for switch locks are:

(1) Unlock the padlock and open the shackle to soak and wash the lock thoroughly in the recommended cleaner (LPS Instant Super Cleaner/Degreaser) or equivalent. This will remove any oil, grease, and their foreign matter from the

area of the locking balls. If feasible, use of an ultrasonic cleaning tank is advised. This type of device produces superior results.

(2) If cleaning by hand, use a squirt bottle to force the cleaning solution into the locking ball cavities. This will complete the cleaning and flushing of the locking ball area.

(3) Do not oil, grease, or graphite the lock. Lubricate only with a light, non-grease substance, such as LPS #1 Greaseless Lubricant.

§300.0(STM) DERAILS

§300.1(STM) Position of Derails

The "normal" position of a derail shall be to derail wheels of rolling equipment away from the main track or structure. The "reverse" position shall permit the unobstructed movement of equipment.

§300.2(STM) Use of Derails

(a) Derails shall be used on all tracks.

(b) Selection of derail type:

(1) A **double switch point derail** will be used at the following locations:

(i) Where the track on which the derail is to be placed descends towards the main track requiring protection.

(ii) On all tracks, even if descending away from the main track, if any portion of that track is higher in elevation than the track at the derail location.

(iii) Where the industry moves rail cars using on or off track equipment or by gravity or with a car puller.

(iv) On tracks used for loading, unloading, or storage of cars containing hazardous (hazmat) materials as defined in the U.S. Hazardous Material Instructions for Rail.

(v) Where operating conditions demand positive derailing protection.

(2) A **sliding rail** may be used where track on which the derail is to be placed is level or descends away from the main track requiring protection.

(3) A **hinge derail** may be used in yard areas where a derail operating stand would adversely impact the normal walking path.

(4) A **portable derail** is used to provide protection to personnel working on or about a track to make work limits inaccessible (see RWP Rules for Operating Railroad Company), or to protect equipment stored temporarily on a track not normally used for storage.

§300.3(STM) Types of Derails

(a) Derails are generally of three kinds: the "split switch," the "sliding block," and the "hinged block" type.

(b) Where derails are prescribed, the split switch type shall be used on side tracks or industrial tracks as follows:

(1) At all locations where the side track or industrial track is on a descending grade to the main track.

(2) Within interlocking limits, in main tracks, in secondary tracks, and as designated by the MassDOT Rail and Transit Division.

(3) In tracks where it is possible for the speed of rolling equipment to exceed 15 MPH.

(c) Approved sliding block type derails shall be used in other than main tracks with speeds less than 15 MPH at other locations than those given in Paragraph (b) above.

(d) Hinged block derails are usually used in yard limits or in conjunction with Roadway Worker Protection (RWP) practices.

§300.4(STM) Installation of Derails

(a) A derail shall be placed a sufficient distance back of the clearance point, not less than 12', to ensure that derailed rolling equipment will not foul the main or other protected track.

(b) When using single point split switch derails, a deflecting rail must be used.

(c) Where deflecting rails are used:

   (1) The minimum length shall be 18'.

   (2) The nearest end shall be 10' from the derail.

   (3) The flangeway opening at the end nearest to the derail shall be 4".

   (4) The end farthest from the derail shall be set to provide a 12" clear opening between running rail opposite the derail and the deflecting rail.

   (5) The deflecting rail shall be of a section and weight that is not greater than that of the running rails, and, preferably less.

   (6) The deflecting rail should be spiked to every tie with two rail holding spikes, one on each side of the rail base.

   (7) Deflecting rails shall be fully anchored or otherwise secured to ensure that they do not move longitudinally.

   (8) Derails are to be installed in accordance with manufacturer's recommendations.

   (9) Existing installations of derails need not be changed to meet these provisions until renewals are necessary, or unless so ordered by the MassDOT Rail and Transit Division.

§300.5(STM) Operation of Derails

(a) Lever stands of approved types may be used for operating derails. Where practicable, the distance from the center line of the lever stand spindle to the gage of the nearest rail shall be at least 50".

(b) Derails shall be provided with standard switch padlocks fastened to the tie by a chain and staple, so that the lever or derail can be locked only in the normal position.

§300.6(STM) Maintenance of Derails

(a) Sliding block or hinged block derails shall be painted yellow.

(b) Dirt and weeds must be kept away from derails.

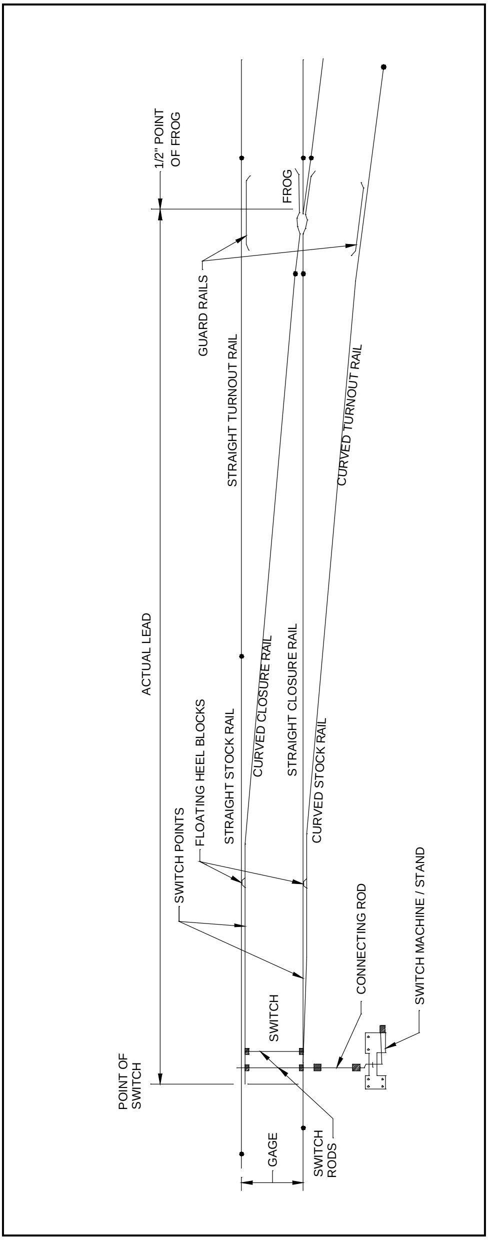
(c) Ballast, snow, and ice must be kept away from derails.

Subpart I – Schematics / Photographs

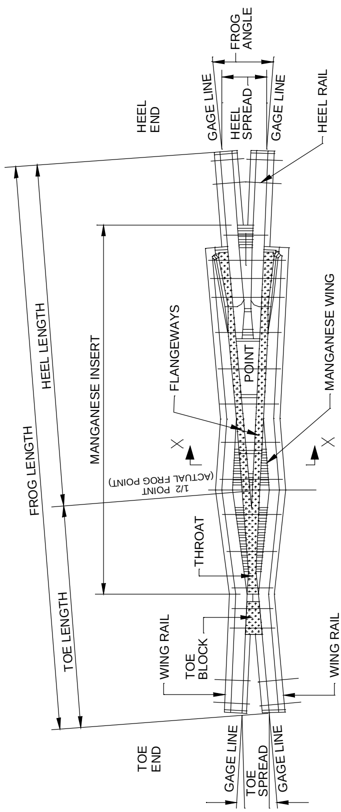
(a) Schematics and photos of trackwork are provided in the MW-1 to illustrate the name, location, and general arrangement of trackwork types and major components.

(b) Trackwork types and components are shown below in photos and drawings and include:

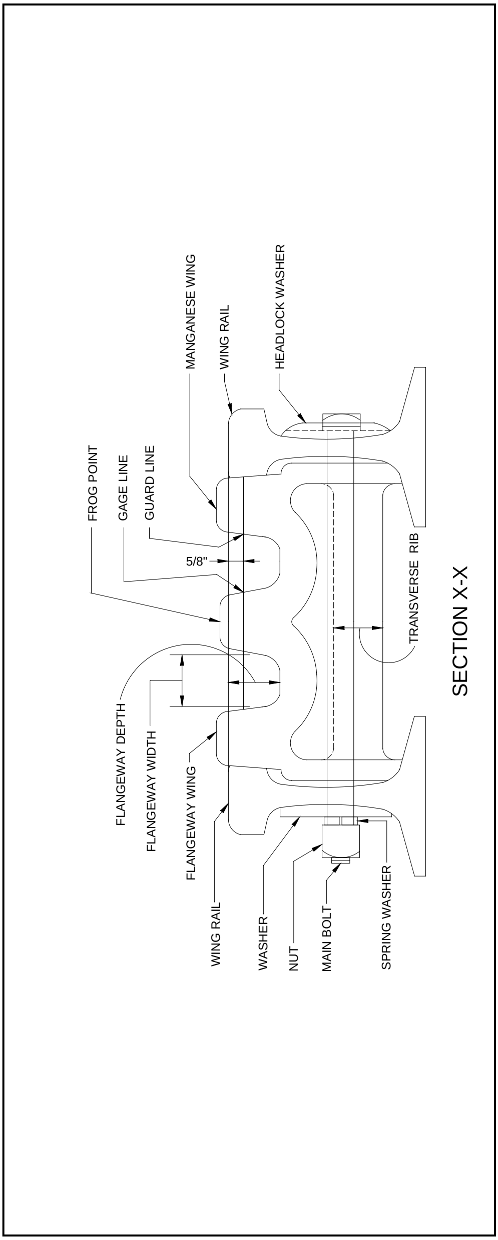
1. Conventional Turnouts
2a. Railbound Manganese Frog (RBM)
2b. Railbound Manganese Frog – Section X-X
3a. Self-Guarded Manganese Frog
3b Self-Guarded Frog – Section Y-Y
4a. Spring Frog Arrangement
4b. Spring Frog Details
5a. Guard Rail - Hook Flange Type
5b. Guard Rail - Hook Flange Type – Section A-A
6a. Hinged Derail
6b. Sliding Block Derail
6c. Double Switch Point Derail
7a. Switch Stand Type 36
7b. Switch Stand Type 36
8a. Western-Cullen Type Bumping Post
8b. High Energy Hydraulic Bumping Post



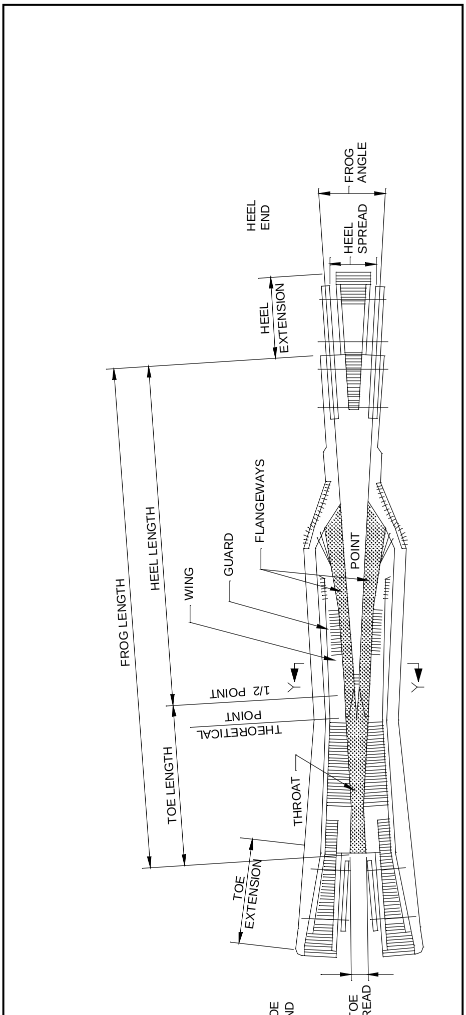
1. Conventional Turnout



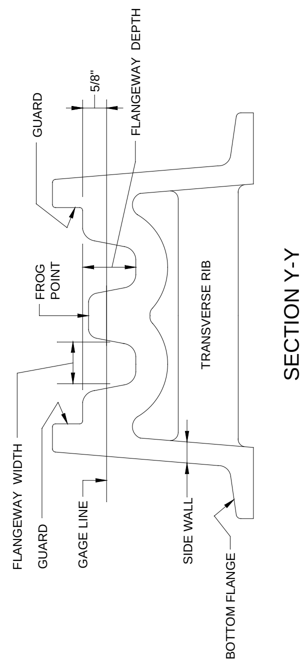
2a. Railbound Manganese Frog (RBM)



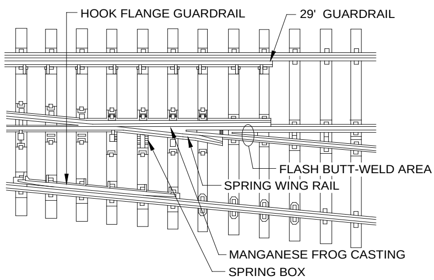
2b. Railbound Manganese Frog – Section X-X



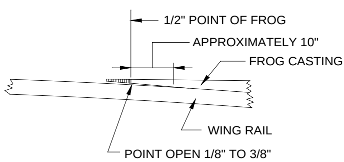
3a. Self-Guarded Manganese Frog



3b. Self-Guarded Frog – Section Y-Y



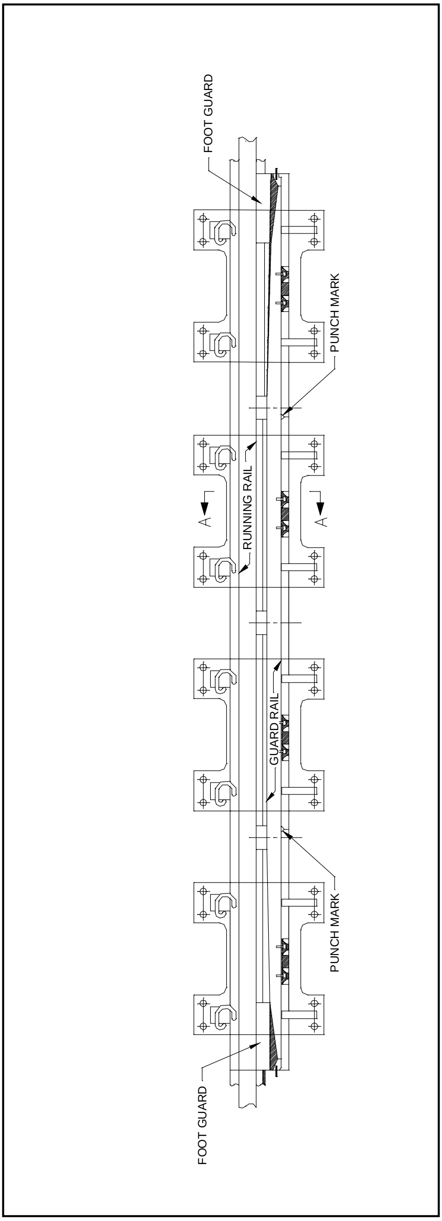
MANGANESE SPRING FR0G LAYOUT



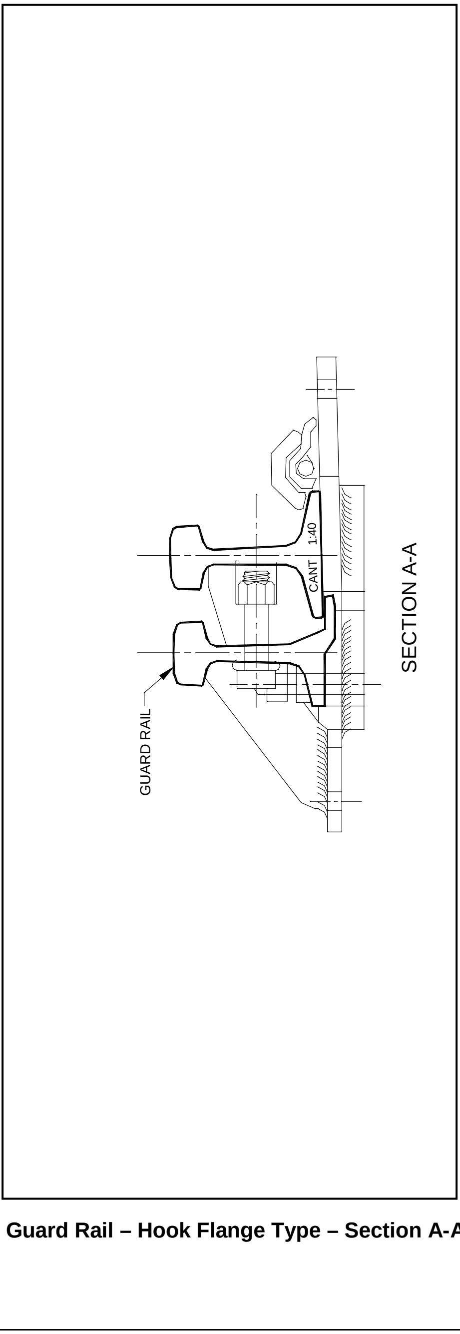
DETAIL OF SPRING FROG POINT AREA

4a. Spring Frog Arrangement

4b. Spring Frog Details



5a. Guard Rail – Hook Flange Type



5b. Guard Rail – Hook Flange Type – Section A-A

6a. Hinged Derail

6b. Sliding Block Derail

6c. Double Switch Point Derail

7a. Switch Stand Type 36

7b. Switch Stand Type 36

8a. Western-Cullen Type Bumping Post

8b. High Energy Hydraulic Bumping Post

APPENDIX A

CONTINUOUS WELDED RAIL (CWR) PROCEDURES

Table of Contents

Attachments

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APPENDIX A

MINIMUM RECOMMENDED REQUIREMENTS TO BE INCLUDED IN THE OPERATING RAILROAD'S CWR PLAN CONTENTS AS PER FRA 213.118 & 213.119

1.0 APPLICABILITY

The installation, adjustment, maintenance and inspection of continuous welded rail (CWR) shall be performed in accordance with FRA Part 213, Track Safety Standard's §213.118 and §213.119. As such, the requirements herein are based on the FRA/Rail Safety Advisory Committee (RSAC) Generic Policy document provided to the U.S. railroads as a part of the October 2009 enacted FRA safety rule and are based on current best practice guidelines on CWR in providing minimum requirements on CWR.

These MassDOT procedures are aimed to aid and assist the Railroad Operating Companies to maintain MassDOT-owned tracks in a safe and efficient manner. Performing CWR installation, maintenance, adjustment and inspection in accordance with the provisions and requirements stipulated herein will meet the expectations of the Commonwealth and provide uniform practice between the different properties of the Railroad Operating Companies.

This document details MassDOT's policy on installing, adjusting, maintaining, and inspecting CWR track. Each section details how the individual MassDOT rail operator applies its standards and procedures to comply with FRA standards.

1.1 INTRODUCTION

(a) Continuous Welded Rail (CWR) is defined as any rail that contains no joints in 400' or greater in length. This document will serve as the recommended practice for the installation, adjustment, maintenance, and inspection of CWR. Rail that is installed as CWR and subsequently has additional joints installed within the limits of the rail will still be considered as CWR, and subject to the requirements of this document. Track laid with CWR is referred to as "CWR Track." Any employee who installs, adjusts, maintains and inspects CWR must have a copy of their approved FRA Plan (§213.118 and 213.119).

(b) If the Operating Railroad cannot comply with the minimum recommended requirements found in Appendix A, they shall immediately notify MassDOT Rail and Transit Division.

(c) Preparation and care:

- (1) **Programmed tie renewals shall be completed in advance of rail laying.**
- (2) **Track shall be surfaced and aligned prior to CWR installation.**
- (3) Track to be laid with CWR must have standard ballast section (shoulders and cribs) for welded rail before CWR is installed.
- (4) Rails should be examined for defects and damage prior to laying in track.
- (5) At the time of installation, care should be taken so that no damage to rail or fastenings will result.
- (6) All ties, to include loose ties, should be tamped to full bearing under the rail, with a small tamper, during rail laying operations ahead of the spiker.

2.0 FABRICATION AND DISTRIBUTION

(a) Unloading:

(1) CWR should be unloaded as close as possible to the position where it is to be installed with a minimum of further handling, giving special attention to accurately locating the ends of CWR.

(2) CWR should be placed parallel with the track and base down, avoiding excessive bending or damage, making use of suitable mechanical equipment when available. Care should be taken to avoid placing rails on drainage facilities and other civil structures.

(3) CWR ends must be bypassed.

(b) Use of CWR on MassDOT Rail and Transit Division owned lines:

(1) CWR fabricated by an approved process may be laid without restriction in fully ballasted main and secondary tracks. When welded rail is laid on curves, particularly those sharper than 6 degrees, it must be closely monitored for any indication of movement up out of the plates.

(2) CWR may be laid across open deck bridges where bridge ties are spaced with timber blocks between ties provided that the following conditions are satisfied:

(i) The anchoring of open deck bridges shall be approved by the Operating Railroad's Bridge Engineer.

(ii) Per MBTA Standard Plan, all ties and blocks in a panel are tightly jacked and fastened together with guard timbers or spacing bars secured by lag screws in every tie. See latest MBTA Standard Plan.

(iii) Per MBTA Standard Plan, bridge ties are securely fastened to steel structure by means of a hook bolts, tie anchors, or other approved holding device. See latest MBTA Standard Plan.

(iv) The bridge structure is properly anchored to abutments and piers to prevent any movement other than normal expansion.

(v) CWR is anchored to the bridge ties in both directions in accordance with Section 4.0 of this document.

(3) After application of hook bolts, tie anchors or other approved holding devices, these devices must be checked and retightened weekly until ties have been fully seated on top flanges of built up members.

3.0 INSTALLATION AND ADJUSTMENT OF CWR

(a) Definitions:

(1) Neutral Temperature: The rail neutral temperature (RNT) is the temperature at which a rail is neither in tension or compression (i.e., when it has zero longitudinal force).

(2) The Rail Laying Temperature (RLT): The temperature at which the rail is installed that is sufficiently high so as to provide a high RNT to prevent possible track buckling.

(i) CWR on MassDOT Rail and Transit Division owned lines shall be installed at an RLT of 105°F with an allowable construction tolerance of -10°F to +10°F or 95°F to 115°F. **The target RLT shall be at least 105°F**.

(ii) When laying and/or distressing rail, the required minimum expansion shall be determined by using a target RLT of at least 105°F (see Section 3.0 and Attachment "B").

(iii) When repairing a service failure to include broken joint bars, pulled apart joints, a broken rail, a broken weld (shop or field), the replacement of a plug

rail or a rail cut in the field, the repair shall be made to ensure that the RNT after the repair is made is at or above RLT-10°F (95°F) (see Attachments A and C).

(3) Temperature Differential: The difference between the target rail laying temperature and the actual rail temperature taken at the time of installation is called the temperature differential (TD).

(i) CWR laying and adjusting procedures have been established to take into account these temperature differences.

(ii) If the rail temperature is below desired RNT of 105°F, the rail must be expanded to the target RLT of at least 105°F.

(iii) The rail expansion required is marked at the quarter points in the field on the string to be expanded.

(iv) RNT is achieved when the correct expansion amounts have been realized at the quarter points.

(v) RNT is not achieved when the required rail temperature of 105°F has been reached unless the required expansion has been realized.

(b) Installation of CWR:

(1) Programmed tie renewals shall be completed in advance of rail laying.

(2) Track shall be placed in good line and surface prior to rail renewals.

(3) Track to be laid with CWR must have standard ballast section for welded rail before installation of CWR.

(4) Rails should be examined for defects and damage prior to laying in track.

(5) At the time of installation, care should be taken so that no damage to rail or fastenings will result.

(6) All ties, to include loose ties, should be tamped with a small tamper to full bearing under the rail, during rail laying operations ahead of the spiker.

(7) Any alignment deviation reduces the temperature at which a track will buckle. As an example, an alinement deviation of about 1" may reduce the buckling temperature from 10 – 15 °F°**.** In addition, an alignment deviation from a Class 5 line defect to a Class 3 line defect (1" to 1 1/8") may reduce the buckling potential by 15 - 20°F, depending on track parameters and conditions."

(8) **The target RLT and RNT is at least 105°F unless approved by the MassDOT Rail and Transit Division.**

(9) CWR shall be anchored or have resilient fasteners applied ("clipped") at a rail temperature of between 95°F and 115°F, unless otherwise directed by MassDOT Rail and Transit Division. This is known as the "Desired Rail Installation Temperature Range."

(10) An approved rail thermometer (magnetic) shall be used to measure the rail temperature of all CWR before it is anchored or clipped. The thermometer should be placed on the web of rail just above the bottom fillet, on the side of the rail that is shielded from the direct rays of the sun and left there long enough (5 minutes) to determine the temperature accurately.

(11) When the rail temperature is lower than the target RNT of 105°F an approved rail heating device or a hydraulic rail stretcher must be used for expanding the CWR to make proper adjustment.

(12) A rail puller can be used to hold the required expansion, and/or to help get the required expansion. At least 20 ties on the next string to be distressed shall be

box anchored and/or clipped to provide sufficient holding power for the rail puller to hold or pull the string being expanded.

(13) Where CWR has been anchored and/or clipped at a rail temperature below 105°F- 10°F (RLT -10°F) and not expanded to the target RNT of 105°F during the rail laying operation, the rail shall be inspected by a person qualified on §213.7(a)(b)(c)(d). A TSR shall be placed, if necessary, and then removed when the rail is expanded to a target RNT of 105°F.

(14) If the CWR is anchored and/or clipped at a rail temperature greater than 115°F (RLT +10°F), up to and including 125°F, the rail may remain in track without restriction.

(15) The following information shall be recorded on the field side web of the individual string (with permanent metal marker) as the strings are being laid:

- (i) String number
- (ii) Date installed or adjusted or distressed
- (iii) Length of string in feet
- (iv) Existing rail temperature/preferred rail neutral temperature
- (v) Total expansion required at end of string (if appropriate)

(16) The person in charge of installing the CWR shall be responsible for recording on the appropriate Form (“CWR Rail Expansion/Heat Record Report”) the amount of required expansion and the rail temperature at each CWR string is anchored. Copies of these forms should be forwarded to MassDOT Rail and Transit Division. See Appendix “E”, Form “RC”.

(17) The “CWR Rail Expansion/Heat Record Report(s)” for any CWR laid in track and or distressed shall be retained by the Railroad Operating Companies until the CWR is readjusted and/or removed from service.

(c) Adjustment/Distressing:

(1) The target RNT is always 105° or greater. When the rail temperature is lower than the target RNT of 105°F an approved rail heating device, a hydraulic rail stretcher or heating by natural means or the ambient temperature shall be used to expand the CWR at its quarter points to achieve proper adjustment.

(2) Adjusting CWR strings to increase RNT by natural means or by using the ambient temperature is allowed only if the unadjusted rail temperature falls in the Desired Rail Installation Temperature Range of RLT -10°F to +10°F or 95°F to 115°F.

(3) All rail anchors and/or resilient fasteners must be removed from strings of CWR requiring adjustment to permit the desired expansion or contraction at the quarter points of the CWR string.

(4) The anchor and/or clip removal should start at the end of the string at the last quarter point to be expanded and move back towards the ¼ point or beginning of the string to be expanded. This is especially important if the rail to be expanded is in compression.

(5) .With conventional cut spikes and plates, an approved mechanical vibratory device may be used to free the rail. Additionally, rail holding spikes shall be pulled if restraining rail movement.

(6) With elastic fasteners and rolled plates, it may be necessary to pick the rail up out of the plates and set on spikes and/or rollers about every 20th tie so as to permit the unrestrained movement of the CWR when being expanded. Again, this process should start from the last quarter point to be expanded and proceed

back towards the ¼ point or beginning of the string to be expanded. This is especially important if the rail to be expanded is in compression.

(7) The rail head must not be struck with a hammer at any time; to include expanding the rail.

(8) CWR should be heated and vibrated so that expansion is introduced from one end of each string to the other end in the direction of rail laying.

(9) All rail anchors or resilient fasteners must be re-applied immediately after the CWR string has achieved proper expansion at the quarter points based upon the target RNT of at least 105°.

(10) The number of inches each CWR string should be expanded during the rail laying operation may be determined by calculation according to the following formula:

$$A = 0.000078 \times (T_D - T_E) \times L$$

where:

A = the amount (inches) of length a CWR string must be increased or decreased to reach the target rail laying or rail neutral temperature

T_E = the existing rail temperature of the CWR before the heating process has begun

T_D = the target neutral temperature or rail laying temperature (105°F) of the CWR at the end of the heating process

L = the length of the CWR in feet

Example: How much expansion is required to adjust the length of a 1,450 ft. CWR string, anchored at a rail temperature of 50°F to the target rail laying/rail neutral temperature of 105°F? Subtract 50°F from 105°F to obtain a difference of 55°F and then multiply as follows:

0.000078 x 1,450 x (105 – 50) = 0.000078 x 1,450 x 55 = 6.22 inches.

Say 6.25 inches

Or use "Change In Rail Length Due To Change In Rail Temperature" Table on the back of Form "RC", "Report of Rail Clipping/Anchoring" found in Attachment E.

(11) A space equal to the amount of expansion required for each string of CWR should be provided between the far end of the string being expanded and the near end of the next adjacent string.

(12) The clipping or anchoring operation shall consist of sufficient personnel so that the work will progress closely enough behind the heating and/or pulling process so that the string is held in place, and no loss of expansion occurs.

(13) Quarter points should be marked on the rail and the tie plate, so that the amount of expansion can be accurately determined. The tie plate used for marking as a reference point must be one that is either doweled or has been spiked, or screw lagged; so that it will not move as the rail expands. Particular attention must be

paid to insure that the rail does not bind on tie plates, spikes or other obstructions.

(14) Heating should commence at the beginning of the first CWR string and steadily applied while moving forward until the required expansion has been obtained at the end of the string. Uniformity of expansion is to be controlled by marking each quarter of the string and introducing expansion as follows:

¼ point - ¼ of total expansion
½ point - ½ of total expansion
¾ point - ¾ of total expansion
End of the string – 100% of total expansion

(15) If when heating, the heated CWR string does not have the required expansion at each quarter point, the heater will back over the heated portion, without applying heat, and then reheat the rail until the necessary expansion is obtained.

(16) During and subsequent to heating, resilient fasteners or anchors shall be applied to the patterns specified in Section 4.0 to prevent the rail from losing expansion. If resilient fasteners fail to hold expansion, rail anchors in the pattern of the following paragraph shall be applied.

(17) Rail anchors and/or clips may be used to control and maintain the expansion realized in a string of CWR while the rail string is being anchored and/or clipped in its entirety. A minimum of 20 consecutive ties shall be solid box anchored and/or clipped at the fully expanded end of the string , to hold the expansion while applying all other anchors and or clips as required.

(18) A rail puller can be used to hold the required expansion and/or to help get the required expansion. At least 20 ties on the next string ahead of the string being distressed shall be box anchored and/or clipped to provide sufficient holding power for the rail puller to hold or pull the string being expanded.

(19) The entire CWR string is to be anchored and/or clipped in accordance with Section 4.0 “Anchoring of CWR” before the track is returned to service and trains are permitted to operate.

(20) An approved rail thermometer (magnetic) shall be used to measure the rail temperature of all CWR before it is anchored or clipped. The thermometer should be placed on the web of rail just above the bottom fillet, on the side of the rail that is shielded from the direct rays of the sun and left there long enough (5 minutes) to determine the temperature accurately.

(21) Where CWR has been anchored and/or clipped at a rail temperature below 95°F (RLT -10°F) and not expanded to the target RNT of 105°F during the rail laying operation, the rail shall be inspected by a person qualified on §213.7(a)(b)(c)(d). A TSR shall be placed, if necessary, and the removed when the rail is expanded to at least 95°F (RLT -10°F).

(22) If the CWR is anchored and/or clipped at a temperature greater than 115°F (RLT +10°F), up to and including 125°F, the rail may remain in track without restriction.

(23) If the CWR is anchored and/or clipped at a temperature greater than 125°F, the rail may remain in track without restriction with the permission of the MassDOT Rail and Transit Division.

(24) The following information shall be recorded on the field side web of the individual string (with permanent metal marker) as the strings are being laid:

(i) String number

(ii) Date installed or adjusted or distressed

(iii) Length of string in feet

(iv) Existing rail temperature/preferred RNT

(v) Total expansion required at end of string (if appropriate)

(25) The person in charge of installing the CWR shall be responsible for recording on the appropriate Form (“CWR Rail Expansion/Heat Record Report”) the rail temperature for which each CWR string is anchored. Copies of these forms should be forwarded to MassDOT Rail and Transit Division. See Appendix “E”, Form “RC”.

(26) The “CWR Rail Expansion/Heat Record Report(s)” for any CWR laid in track and or distressed shall be retained by the Railroad Operating Companies until the CWR is readjusted and/or **removed from service.**

4.0 ANCHORING OF CWR

(a) CWR Rail Anchoring Requirements: The following anchoring requirements apply to all CWR tracks.

(1) Existing anchor patterns may remain in place until CWR is installed.

(2) Where the anchoring function is otherwise provided, such as with a resilient fastener, rail anchors may be omitted.

(3) Anchors may not be applied where they will interfere with signal or other track appliances or where they are inaccessible for adjustment or inspection.

(4) Anchoring must effectively restrain the longitudinal rail movement.

(5) Rail must be adjusted and/or anchors must be added to rail that is moving, or where the existing anchors do not have effective holding power to restrain longitudinal movement.

(6) Anchor pattern may be varied, if possible, to avoid placing anchors against deteriorated ties.

(7) When a crosstie has four properly installed resilient fasteners, or four properly installed rail anchors, it will be considered to be fully box anchored tie.

(b) When laying or distressing welded rail, rail anchors are used to maintain the desired expansion and length of CWR strings. Crossties shall be fully box anchored in accordance with the following:

(1) Every Tie:

(i) Curves 3° and over

(ii) Through all rails of turnouts and crossovers, where practicable

(iii) For 195’ in each direction from:

a. Main track turnouts and crossovers
b. Track crossings (diamonds)
c. Highway grade crossings
d. On the fixed side of expansion joints
e. On the approaches to open deck bridges
f. On both sides of all insulated joints (bonded and/or non-bonded)
g. On both sides of hot box, dragging equipment and wheel impact load detectors
h. Before bumping posts

(2) Every Other Tie:

(i) Through the remainder of CWR strings where full boxing is not specified above.

(3) Bridge Anchor Patterns:

(i) Ballast deck bridges should be anchored with the same pattern as the rail on each approach to the bridge.

(ii) Open deck bridges should be anchored according to the following table or as approved by the MassDOT Rail and Transit Division:

Length of Continuous Open Deck Portion (ft.)**	**Individual Span Length (ft.)**	**Rail Anchor Requirements**	**Sliding Joint Requirements**
100 ft. or less	All spans	Every 3rd or 4th tie. See §111.0(M) Bridge Timbers*	None required
Greater than 100 ft.	100 ft. or less	Every 3rd or 4th tie. See §111.0(M) Bridge Timbers*	None required
	Greater than 100 ft.	Every 3rd or 4th tie. See §111.0(M) Bridge Timbers*	As per requirements of MassDOT Rail and Transit Division

* Box anchors are to be applied only to ties that are hook bolted to the span.
**See MBTA Book of Standard Plans Drawing Nos. 1232 and 1236.

(4) Other Anchor Patterns:

(a) Under pavement off the ends of grade crossing panels.

(b) Under grade crossing surfaces as per crossing surface manufacturer.

(c) In areas adjacent to the expansion side of expansion joints as authorized and approved by MassDOT Rail and Transit Division.

(c) Anchor Requirements After Making Rail Repairs in CWR and Adding Joints:

(1) When repairs are made to stripped joint or failed bar on CWR that already exists in track, the adjustment or addition of anchors will be as prescribed below:

Condition	Action
Bolted joint in CWR experiencing a service failure (pull-apart) or failed bar(s) with gap* present (FRA §213.119(c)(3)	Weld Joint, **OR** Remediate Joint conditions **and** replace four (4) bolts (new, in-kind or stronger) **and** weld joint within 30 days, **OR** Replace broken bar(s), install 2 additional bolts (6 total) and adjust anchors (ballast permitting), **OR** Replace bars, bolts (if broken or missing) and anchor every tie for 195' in both directions (ballast permitting) **OR** Add rail and make out Form "TD" and make future repairs
* Gap exists if it cannot be closed with a drift pin.	

5.0 MAINTENANCE OF THE DESIRED RAIL NEUTRAL TEMPERATURE IN PREVIOUSLY INSTALLED CWR

(a) **Maintaining Desired Neutral Temperature Range: Broken or Defective Rail, Pull-Apart (Service Failures) And/or Tight Rail or Track Buckle**

(1) This section addresses repairs for broken or defective rail, and corrections made for tight rail, track buckle or pull-apart.

(2) Also see Attachments A, B, and C.

(3) When performing this work, care shall be taken not to add rail to the track.

(4) In general, if a length of rail is installed in CWR, it should have a length less than the rail removed and/or not exceed the length of rail removed (DO NOT ADD RAIL).

(5) Before joint bars are removed and/or a rail is cut, reference marks shall be added at tie plates and on the base of the rail. Reference marks can be used to determine how much the joint opens, or how much rail is cut out (if rail is in compression) or how much rail is added.

(6) The use of reference marks includes:

- Marking the locations where the joint is to be removed or the rail is to be cut
- Marking the rail outside the limits of the joint bars
- Measuring the distance between the reference marks and mark it on the rail
- Installing the rail and re-measure the distance between reference marks
- Recording the difference and documenting the location

(7) If rail is added for any reason, such as repairing a pull-apart, making emergency repairs, fixing a service failure or any other interim repair, measure and record the amount of rail added on Form "TD" so that adjustments can be made before reaching the rail return temperature.

(8) Existing RNT shall be estimated where the rail has pulled apart, broken, or been cut for defect removal by using the appropriate charts in Attachment A.

(9) To determine the pre-break/cut RNT, record the length of the rail end gap, rail temperature, rail base size and existing rail anchorage and use tables in Attachment "A".

(10) The estimated pre-break/cut RNT shall be recorded on Form "TD" so that additional required repairs, if any, can be tracked and done before rail return temperatures are exceeded (see Attachment C).

(11) Work performed by Railroad Operating Companies, such as rail that has pulled apart, broken, or been cut for service failures to make repairs to CWR, shall be readjusted to a preferred RLT or RNT of 105°F +/- 10°F**. The minimum RNT is 95°F** (see Section 3.0).

(12) If rail has not been adjusted before rail return temperatures exceed the values in Attachment C, then a temporary speed restriction (TSR) of 25 MPH shall be placed. A TSR of 40 MPH may be placed if a required daily inspection is made during the heat of the day, every day, **until the adjustment and permanent repair is made.**

(13) For detailed procedures on adjusting pulled apart, broken, or cut rail, refer to Attachment C.

(b) **Adjusting or Distressing Previously Installed CWR**

(1) Rail can be distressed by heating rail and/or pulling rail that has a RNT below the target RLT of 105°F. In a curve, the CWR can be distressed or the curve can be lined out. When distressing or adjusting CWR with an RNT below the target RLT of 105°F, the following is a *general* procedure:

(2) Procedure:

(i) Determine amount of rail to be distressed on either side of a cut and/or joint (up to 800' on either side of the joint and/or cut for a total of 1,600' maximum).

(ii) Cut rail at the end or in center of rail to be distressed (see Attachment B).

(iii) Remove anchors or clips in both directions from either side of the cut back to the distressing limit or to a fixed object or an appliance in the track (turnout or grade crossing) or structure that prevents rail movement.

(iv) Wait until rails stop moving. The rail ends may need to be misaligned to allow for expansion and then trimmed one time (if possible) to fit.

(v) Take the rail temperature.

(vi) Compare the rail temperature to the target RLT=105°F to determine the temperature differential (TD).

(vii) If the actual rail temperature is lower than the RLT of 105°F, use the Rail Expansion Table in Attachment E (Form "RC") to determine the rail length to be removed based on the total distance the anchors or clips that have been removed.

(viii) Expand rail required amount by using ambient temperature, rail heater and/or rail puller.

(ix) Replace the rail anchors or clips.

(x) Weld the joint or apply joint bars:

- When making an orgothermite field weld, cut out required amount of rail plus the weld width allowance as specified by the weld manufacturer. **(**Typically **1"+/-)).**
- When making an electric flash butt field weld, the amount of rail to be cut is the amount determined from the rail expansion table minus the

amount of rail consumed when making the electric flash butt weld. (Typically 3/4" to 1-1/2")**.**

(3) All other provisions of Section 3.0 apply to this process.

(c) **Procedures for Making Repairs to Buckled Track**

(1) In the event of buckled track, the following conditions exist and procedures are to be used as a guideline:

(i) Since both rails are assumed to be in compression, cut both rails with a torch.

(ii) Make these torch cuts out of the displaced track zone where there may be significant compressive stress in the rails.

(iii) Torch cuts shall be at least one rail length (39'+) beyond the end of lateral track displacement.

(iv) If possible, before cutting the rail, line the track at the point of displacement in the direction of the displacement to further reduce the compressive stresses in the rail. If the displaced area is near a joint then the joint bars should be removed after lining the track.

(v) Misalign the cut and/or uncoupled rail ends, allowing the ends to bypass.

(vi) Bring the track back into correct alignment.

(vii) Both rails for some distance on either side of the point of maximum displacement and/or the point where rails were cut or the joint bars were removed are now considered to have lost their adjustment.

(viii) These rails must be readjusted and/or distressed according to this Section.

(ix) Also, see Attachment B: "Recommended Procedures for Distressing Continuous Welded Rail (CWR) Previously Laid In Track": "Reactive or Emergency Distressing".

(x) Track buckle at a fixed object:

- In those cases where the buckle occurs at a fixed object (grade crossing, turnout, etc.) the readjustment/distressing need only take place in the direction away from the fixed object,
- However, a close inspection of the track on the other side of the fixed object is required to determine if there is any evidence of rail or track movement, rail bunching, etc. which may indicate inadequate adjustment in that area and the need for additional distressing.

(xi) If the area cannot be readjusted or repaired before running a train, appropriate remedial action shall be taken:

- A Form "TD" shall be filled out so that necessary distressing work can be accomplished before return rail temperatures are exceeded (see Attachment C).
- Alignment measurements should be taken to ensure that the track meets minimum alignment requirements for the Class of Track at which the track is to be returned to service as is shown in the FRA Track Safety Standards §213.55**.**
- Rails that have been torch cut during the corrective procedure will be either cut back and/or removed from track promptly (see Attachment B).
- On MassDOT Rail and Transit Division owned rail lines, torch cut rails shall be protected by a maximum 10 MPH (F&P) temporary slow order (TSO) until the rail is cut back and/or removed from track.

(xii) New rail adjustment and rail clipping records shall be prepared on the Rail Clipping/Anchoring Form "RC" with the new adjusted temperatures when the rail in the affected area is distressed (see Attachment E).

(xiii) The original Form "TD" that was made out at the time of the incident shall be updated to indicate that all necessary repairs, to include distressing, have been made, when the permanent repairs are made.

(xiv) The Operating Railroad shall retain Form "RC" for the record for the duration of their Operating Contract and/or until the rail is removed from service. A copy of Form "RC" shall be sent to the MassDOT Rail and Transit Division.

(d) **Installing Rail Plugs in Existing CWR Track**

(1) When it is necessary to install rail plugs in existing CWR due to replacement of defective rails, defective field or plant welds, defective joints or insulated joint failures, etc., an approved heating device or hydraulic expander must be used to **assure the amount of rail installed is equal to or less than the length of rail removed. DO NOT ADD RAIL**

(2) If the work cannot be completed and a permanent repair cannot be made before running a train, appropriate remedial action shall be taken:

(i) A Form "TD" shall be filled out to document work done so that the necessary permanent repair can be accomplished before return rail temperatures are exceeded (see Attachment C).

(3) **Where necessary to install a plug rail in CWR, use at least a 14' long plug in tangent and at least a 21' plug in curves wherever possible.**

(4) See FRA §213.119(c)(3): If it becomes necessary to apply joint bars in CWR already laid in track, because of a service failure or a failed bar with a rail gap present:

(i) Weld the joint (The end bolt hole in each rail end must not be drilled to permit field welding);

(ii) Replace broken bar(s), replace broken bolts, adjust anchors and within 30 days, weld the joint;

(iii) Replace the broken bar(s), replace the broken bolts, install one additional bolt per rail end (six hole bar needs six bolts), and adjust anchors;

(iv) Replace the broken bar(s), replace the broken bolts, and anchor every tie 195 feet in both directions from the CWR joint.

(e) **Field Welding of CWR**

(1) When field welding joints with orgothermite welds between CWR strings that have been temperature adjusted, or field welding plugs previously installed in properly adjusted CWR track:

(i) **The necessary gap for welding will not be developed by allowing the rail gap to open up to the correct welding gap.**

(ii) The following welding practices shall be used:

- Remove the joint bar. Remove with an approved rail saw 1"+/- of rail, or as specified by weld manufacturer, to provide the required welding gap. If a "Wide Gap" field weld is to be used, the gap shall be as required by the weld manufacturer. Torch cutting of rail is prohibited. **DO NOT ADD RAIL**
- To maintain the proper weld gap apply a hydraulic expander to return the rail ends to the required gap and while holding this position,

proceed to make the weld in accordance with existing procedures. Let field weld cool to 500°F before removing expander.

- Upon completion of weld reapply anchors and/or clips before removal of the hydraulic expander.

(2) All other provisions contained in §121.1(M), "Field Welding of Rail Joints," of the MW-1 will be followed when field welding is conducted.

6.0 TRACKWORK THAT DISTURBS CWR TRACK AND THE PROTECTION OF DISTURBED TRACK

6.1 General

The following trackwork repairs are considered to disturb CWR track.

6.1.1 Trackwork that Disturbs CWR

(a) Trackwork activities discussed below are repairs and/or production work that are considered to have disturbed CWR track.

(b) **Trackwork activities that disturb CWR track** shall be inspected by a qualified person as designated in FRA §213.7(a)(b)(c).

(c) Before returning the track to service, the above designated person in (b) shall take appropriate remedial action and place a TSR as given in this Section 6.0.

(d) The designated qualified person as given in (b) shall place more restrictive TSRs and additional remedial action as conditions warrant.

6.1.2 Trackwork that Does Not Disturb CWR

(a) **Trackwork activities that do not disturb CWR track** shall be inspected by a qualified person as designated in FRA §213.7(a)(b)(c).

(b) Before returning the track to service, the above designated qualified person in (a) shall take any appropriate remedial action that that person sees fit to protect the safety of train operations.

6.2 Train Definition

(a) For the purposes of this part, a train is defined as:

(1) A locomotive and at least eight loaded ballast cars (80 ton cars each) (1,000 ton +/- consist), or

(2) A commuter train with at least five cars and a locomotive (750 ton +/- consist), or

(3) Some combination of railroad equipment that is 1,000 ton consist (including locomotive), or

(4) A ballast stabilizer that is equivalent to 50 tonnage trains (1,000 tons each) or 50,000 tons, or

(5) As approved by MassDOT Rail and Transit Division.

6.3 Work Activities that Disturbs CWR Track

(a) **Installation of Plugs in CWR that Disturbs CWR Track:**

(1) If, during the installation of a plug rail in CWR, rail has been added or RNT as determined by measurement of rail gap is less than 95°F or (RNT-10°F) see Attachments A and C and the following:

(i) Install the rail anchors reversed on field side of plug rail only until necessary permanent repairs are made; or

(ii) Spray the elastic fasteners on the gage side in orange paint until necessary permanent repairs are made.

(iii) Fill out Track Disturbance Report (Form "TD"). The amount of rail added, as well as the temperature and rail gaps of the rail at the time of the break or

saw cut, **shall** be reported on Form "TD", "Record of Disturbance of Main CWR Track."

(iv) Make temporary and/or permanent repairs as given in Attachment C using tables in Attachment A as required.

(v) The track shall be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(2) **Protective Slow Order**: See Table in Attachment C for maximum rail temperatures (°F) at which permanent repairs or readjustments shall be made and/or slow orders applied. **When these rail temperatures exceeded a TSR of no more than 25F and 25P MPH shall be placed on the track in question until repairs are made, unless inspected daily in the heat of the day, in which case the TSR can be no more than 40F and 40P MPH**

(3) Repairs shall be accomplished in accordance with Section 5.0 and Attachments C and A.

(4) Following steps (1) and (2), when permanent repairs have been made, the track will be returned to maximum authorized speed (MAS) unless additional deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(5) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work such as installing plug rails shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(b) **Tie Renewal In Tangent Track and in Curves <3° that Disturbs CWR Track:**

(1) Installing more than four ties in 39' of track with four undisturbed ties between renewed ties; or

(2) Installing four or less than four ties per 39' of track with fewer than four undisturbed ties between renewed ties.

(3) In any case no more than four ties per 39' of track (540 ties per mile) can be replaced in one pass.

(4) **When old ties are removed, and new ties and plates installed, do not lift the rail.**

(5) **When tamping ties installed, tamper should be set so that no lifting of the track occurs.**

(6) **MassDOT shall review means, methods, and equipment before ties are removed and installed.**

(7) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(8) Ties shall not be installed at ambient temperature of less than 40°F unless approved by the MassDOT Field Representative.

(9) Fill out Track Disturbance Report (Form "TD").

(10) The track shall be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(11) **Protective Slow Order (without stabilizer) (Ambient ≤80°F):** Not to exceed 25F and 30P MPH shall be applied for a period of 24 hours and a minimum of 12 trains over the affected track.

(12) **Protective Slow Order (with stabilizer) (Ambient ≤80°F):** Not to exceed 25F and 30P MPH shall be applied for the first train over the affected track.

(13) **Protective Slow Order (with or without stabilizer) (Ambient >80°F):** If ambient temperature >80°F and rail temperature is >110°F, a slow order of 10F and 15P shall be applied until the ambient temperature drops to 80°F. When the ambient temperature is ≤80°F, the Protective Slow Order applied is described as above in (11) or (12).

(14) Following steps (11) and/or (12), (13), track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(c) **Tie Renewal in Curves ≥3° that Disturbs CWR Track:**

(1) In addition to the protective action required when installing ties in tangent track in Paragraph (b) above, if 540 ties per mile or more are installed in curves ≥3° the following shall be done:

(i) The curve or curves ≥3° in question shall be staked as described in Attachment E, using Form "TM," Report of Track Movement.

(ii) Movement of the curve(s) when ties are installed shall be recorded on Form "TM"; and,

(iii) If a curve greater or equal to 3° moves inward and/or outward when installing ties, the curve shall be inspected by a person qualified under FRA §213.7(a)(b)(c), and appropriate remedial action taken as conditions warrant.

(iv) If movement limits to the inside of the curve are exceeded then the RNT shall be adjusted by distressing the rail in the curve and/or lining the curve out (see Attachment B).

(2) **When old ties are removed, and new ties and plates installed, do not lift the rail.**

(3) **When tamping ties installed, tamper should be set so that no lifting of the track occurs.**

(4) **MassDOT shall review means, methods, and equipment before ties are removed and installed.**

(5) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(6) Ties shall not be installed at ambient temperature of less than 40°F unless approved by the MassDOT Field Representative.

(7) Fill out Track Disturbance Report (Form "TD") and Report of Track Movement (Form "TM") as appropriate.

(8) **Protective Slow Order (with or without stabilizer) (Ambient ≤80°F)**: Same as for Tie Renewal in Tangent Track if curve movement for curves ≥3° is less than 3"as given on the table for Form "TM" (see Attachment E for table).

(9) **Protective Slow Order (without or with stabilizer) (Ambient >80°F):** If ambient temperature is >80°F and rail temperature is >110°F, a slow order of 10F and 15P MPH shall be applied until the ambient temperature drops below 80°F. When the temperature drops below 80°F, the Protective Slow Order is applied as described above in (8).

(10) **Protective Slow Order for Curve Movement (with or without stabilizer) (Ambient ≤80°F)**: If a curve ≥3° has movement ≥3" to the inside (see Form "TM," Attachment E), a protective slow order not to exceed 25F and 30P shall be applied. In addition:

(i) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(ii) The restriction shall remain in effect until the curve is lined out back to its original position and/or both rails are readjusted to the target neutral temperature of 105°F in accordance with Section 3.0 and Attachment B

(11) **Protective Slow Order for Curve Movement (with or without stabilizer) (Ambient >80°F)**: If a curve ≥3° has movement ≥3" to the inside (see Form "TM," Attachment E), a protective slow order not to exceed 10F and 15P shall be applied. In addition:

(i) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(ii) The slow order of 10F and 15P MPH shall be applied until the ambient temperature drops below 80°F. When the temperature drops below 80°F, the protective slow order is applied as described above in (10); and

(iii) The restriction of 25F and 30P shall remain in effect until the curve is lined out back to its original position and/or both rails are readjusted to the target neutral temperature of 105°F in accordance with Section 3.0 and Attachment B.

(12) Following steps (7) through (11), track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(d) **Surfacing, Smoothing and/or Lining that Disturbs CWR Track (Tangent and Curves <3°):**

(1) **The normal balancing of throws done during high speed surfacing operations does not constitute out-of-face curve realignment.**

(2) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(3) If the ambient temperature and/or rail temperature is less than 40°F, all work will be suspended unless it is an emergency or directed by the MassDOT Field Representative.

(4) **Protective Slow Order: T**he protection of CWR Track which has been surfaced is shown in the following table, "Protection Required for CWR Track Surfaced Based on Air and Rail Temperatures."

(5) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(6) When operating speeds change during the time a restriction (TSR) is in effect, the worked track must be re-inspected by a qualified Operating Railroad Employee each time the speed is to be raised.

(7) Whenever a dynamic stabilizer is to be used as part of a surfacing operation, it will be:

(i) Operated after each pass of the tamper; and

(ii) Both vibration units must be fully operable and the frequency of oscillation shall be in the range of 30-35 Hz, with a minimum vertical loading pressure of 870-1,000 psi and working speed shall be in the range of 1-2 MPH.

(iii) A ballast compactor may be used if approved by MassDOT Rail and Transit Division.

Protective Slow Order Required for CWR Track Surfaced Based on Air and Rail Temperatures

Air Temperature	Distance	Wood Tie Track Protection	Concrete Tie Track Protection
Applies to ALL Surfacing: STOP Work			
Ambient Does Exceed 80° or the and Rail Temperature Exceeds 110°F***	All Distances	STOP Work	STOP Work
Protections to be applied for Surfacing with NO Dynamic Stabilizer			
Ambient Does Not Exceed 80° (Rail Temp ≤110°F)	0 ft. to 19'-6" Over 19'-6"	None* 25F-30P MPH for 24 hours **and** the passage of 12 trains	None* 25F-30P MPH for 24 hours **and** the passage of 12 trains**
In an Emergency, Ambient Does Exceed 80° (Rail Temp >110°F)	All Distances Ambient >80°F All Distances Ambient ≤80°F	10F-15P MPH until ambient temperature ≤80°F 25F-30P MPH for 24 hours **and** the passage of 12 trains	10F-15P MPH until ambient temperature ≤80° 25F-30P MPH for 24 hours **and** the passage of 12 trains**
Protections to be applied for Surfacing USING a Dynamic Stabilizer			
Ambient Does Not Exceed 80° (Rail Temp ≤110°F)	All Distances WITH the use of a Dynamic Stabilizer	10F-15P MPH for the first train 25F-30P MPH for the second train, Then Normal Speed	10F-15P MPH for the first train 25F-30P MPH for the second train, Then Normal Speed
In an Emergency, Ambient Does Exceed 80° (Rail Temp >110°F)	All Distances WITH the use of a Dynamic Stabilizer	10F-15P MPH first train 25F-30P MPH for the second train, Then not more than 40F-60P MPH for the passage for 24 hours and 12 additional trains	10F-15P MPH first train 25F-30P MPH for the second train, Then not more than 40F-60P MPH for the passage for 24 hours and 12 additional trains

* If the air temperature does exceed 80°F (rail temperature exceeds 110°F) during the 24 hours following the work then a 25F-30P MPH restriction must be placed on the worked area for 24 hours and the passage of 12 trains.

** A restriction with a speed no greater than 40F-60P MPH may be applied only if a Shoulder and Crib Compactor is used immediately after surfacing. If a restriction greater than 25F and 30P MPH is applied, the first train over the affected area must be limited to 25F and 30P MPH.

***If the air temperature exceeds 80°F and the rail temperature exceeds 110°F, there is no work permitted except in an emergency or as directed by MassDOT Rail and Transit Division.

(e) **Surfacing, Smoothing and/or Lining that Disturbs CWR Curved Track: Curves $\geq$3°**:

(1) **The normal balancing of throws done during high speed surfacing operations does not constitute out-of-face curve realignment.**

(2) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(3) If the ambient temperature and/or rail temperature is less than 40°F, all work will be suspended unless it is an emergency or directed by the MassDOT Field Representative.

(4) Curves 3° or over being surfaced and aligned shall be staked to monitor movement.

(i) To stake a curve, place reference points uniformly around the curve in the track along the gage side of the high rail, starting at the tangent to spiral point (TS). As a minimum, tag and stake the following points:

- Tangent to Spiral Point (TS)
- Spiral to Curve Point (CS)
- Full Body of Curve: at least every 200’
- Curve to Spiral Point (CS)
- Spiral to Tangent Point (TS)

(ii) The reference points shall be 200' or less apart. Each reference point around the curve shall be staked on the field side of the high rail (where possible). Stakes should be set a minimum of 15’ from the gage corner side of the high rail out of the way of ballast unloading and the ballast regulator wings.

(iii) The reference points are to be recorded on Form “TM,” “Report of Track Movement” (see Attachment E).

(iv) Measure from the reference points to the stakes on the field side of the high rail to obtain initial values of distance between reference points and stakes before any work is conducted and record on Form “TM”.

(v) The reference point to stake distances shall be re-measured immediately after the final surfacing pass by the surfacing gang. These measurements are made to determine track movement, if any, at the reference points. The measurements shall be measured and recorded on Form “TM” before track is returned to normal speed.

(vi) In addition, the track movement at the reference points should also be re-measured seven days after the work is completed.

(vii) Track movements shall be calculated and compared to the values given on Form “TM” (see Attachment E).

(5) **Protective Slow Order (any temperature):** If in surfacing and aligning a curve $\geq$3°, the limits of out-of-face curve realignment given in Attachment E, Form “TM”, are NOT EXCEEDED:

(i) If the curve is moving outward and/or inward, inspect the curve with a person qualified under FRA §213.7(a)(b)(c), and provide protection and/or TSRs as given in Section 6(d), “Surfacing, Smoothing and/or Lining that Disturbs CWR Track (Tangent and Curves <3°)”; or

(ii) If the curve is moving outward and/or inward, inspect the curve with a person qualified under FRA §213.7(a)(b)(c), and, if conditions warrant, take

remedial action ad provide more restrictive protection than required in Section (6)(d), "Surfacing, Smoothing and/or Lining that Disturbs CWR Track (Tangent and Curves <°3)."

(6) **Protective Slow Order (when curve movements in Attachment E, Form "TM", are exceeded):** If in surfacing and aligning a curve $\geq$3°, the limits of out-of-face curve realignment ($\geq$3") given in Attachment E, Form "TM" are exceeded ($\geq$3"), proceed as follows.

(i) Fill out Form "TD" Track Disturbance Report and Form "TM" Report of Track Movement.

(ii) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(iii) The curve will have been considered to have lost its neutral temperature and will have to be adjusted in accordance with Section 3.0, "Installation and Adjustment of CWR" and/or realigned out to original position as determined by staking.

(iv) **Protective Slow Order (Ambient $\leq$80°F):** Not to exceed 25F and 30P MPH until rail has been cut and RNT adjusted to 105°F and/or curve has been lined out to original position.

(v) **Protective Slow Order (Ambient >80°F):** Not to exceed 10F and 15P until:

- The ambient temperature drops below 80°F. When the temperature drops below 80°F, the protective slow order is applied as described above in (iv) above; and.
- The restriction of 25F and 30P shall remain in effect until the curve is lined out back to its original position and/or both rails are readjusted to the target neutral temperature of 105°F in accordance with Section 3.0 and Attachment B

(7) Following steps (4) through (6), the track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(f) **Cut and Throw of Track that Disturbs CWR Track:**

(1) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(2) When existing CWR track is cut and thrown, it will be considered to have lost its neutral temperature and will have to be adjusted in accordance with Section 3(b). **DO NOT ADD RAIL.**

(3) Fill out Track Disturbance Report (Form "TD").

(4) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(5) **Protective Slow Order (Ambient $\leq$80°F):** Not to exceed 25F and 30P MPH shall be applied until RNT is readjusted to 105°F.

(6) **Protective Slow order (Ambient >80°F):** Not to exceed 10F and 15P MPH until RNT is readjusted to 105°F.

(7) The area of cut and throw will have been considered to have lost its neutral temperature and the RNT shall be adjusted in accordance with Section 3.0, "Installation and Adjustment of CWR."

(8) RNT adjustments shall be made before the ambient and rail temperatures reach those given in (1).

(9) Following steps (3) through (8), the track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(g) **Switch or Track Panel Installation that Disturbs CWR Track:** When performing panel installation, the following requirements apply:

(1) Fill out Track Disturbance Report (Form "TD").

(2) Switch and track panel installation shall only be performed at ambient temperatures greater than 30°F unless it is an emergency or as directed by MassDOT Rail and Transit Division; and,

(3) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(4) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(5) The area of switch or track panel installation will have been considered to have lost its RNT if:

(i) Rail has been added when the switch and track panel has been installed.

(ii) This can be determined by placing match mark on the rail before the track is cut to install the switch and/or track panel and by measuring the rail gap.

(6) If RNT has been lost, the rail shall be adjusted to a target RNT of 105°F in accordance with Section 3.0, "Installation and Adjustment of CWR."

(7) If rail has been added, a protective slow order shall be placed until the adjacent CWR and RNT is adjusted. These RNT adjustments shall be made before the ambient and rail return temperatures are exceeded as given in Attachment C. These temperatures are related to the rail temperature at which the rail was cut to install the track or switch panel.

(8) **Protective Slow Order (Ambient ≤80°F) (until rail neutral temperature adjustment):** Not to exceed 25F and 30P shall be applied until the RNT adjustment work is accomplished.

(9) Protective Slow Order (Ambient >80°F) (until rail neutral adjustment): Not to exceed 10F and 15P MPH shall be applied until the RNT adjustment work is accomplished.

(10) In addition, the track panel has lost all its lateral stability and the CWR is considered disturbed until the ballast section is restored and recompacted/stabilized by machine action and/or by train traffic.

(11) **Protective Slow Order (at any ambient Temperature) (with correct RNT) (to consolidate ballast without stabilizer):** Place a protective slow order not to exceed 25F and 30P MPH will be applied after surfacing, for a period of 24 hours ***and*** a minimum of 12 trains over the affected track.

(12) **Protective Slow Order (at any ambient Temperature) (with correct RNT) (to consolidate ballast with stabilizer):** Not to exceed 25F and 30P MPH shall be placed for a period of 24 hours and a minimum of three trains over the affected track if a stabilizer has been used.

(13) Following steps (4) through (12), the track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(h) **Undercutting that disturbs CWR track:** When performing this work, the following requirements apply:

(1) Fill out Track Disturbance Report (Form "TD").

(2) Undercutting shall not be done at an ambient temperature below 30°F and above 80°F (rail temperature greater than a temperature of 110°F) except in an emergency and as approved by MassDOT Rail and Transit Division.

(3) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(4) When undercutting track, the neutral temperature shall be considered lost and the rail will have to be adjusted to a target RNT of 105°F in accordance with Section 3.0, "Installation and Adjustment of CWR."

(5) These RNT adjustments shall be made before the ambient and rail return temperatures are reached as given in Attachment C. These temperatures are related to the rail temperature at which the rail was undercut and the existing RNT was substantially altered.

(6) **Protective Slow Order (Ambient $\leq$80°F) (until rail neutral temperature adjustment):** Not to exceed 25F and 30P shall be applied until the RNT adjustment work is accomplished.

(7) **Protective Slow Order (Ambient >80°F) (until rail neutral adjustment):** Not to exceed 10F and 15P MPH shall be applied until the RNT adjustment work is accomplished.

(8) **Protective Slow Order (at any ambient Temperature) (with correct RNT) (to consolidate ballast without stabilizer):** Place a protective slow order not to exceed 25F and 30P MPH will be applied after surfacing, for a period of 24 hours ***and*** a minimum of 12 trains over the affected track.

(9) **Protective Slow Order (at any ambient Temperature) (with correct RNT) (to consolidate ballast with stabilizer):** Not to exceed 25F and 30P MPH shall be placed for a period of 24 hours and a minimum of three trains over the affected track if a stabilizer has been used.

(10) Following steps (3) through (9), the track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(i) **Out-of-Face Shoulder Ballast Cleaning that Disturbs CWR Track:**

(1) Fill out Track Disturbance Report (Form "TD").

(2) Out-of-Face shoulder ballast cleaning shall not be done at an ambient temperature below 30°F and above 80°F (rail temperature greater than a temperature of 110°F) except in an emergency and as approved by MassDOT Rail and Transit Division.

(3) After shoulder ballast cleaning is performed, there shall be a full restoration of the standard ballast section to include cribs and shoulders.

(4) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(5) **Protective Slow Order (with compactor and/or stabilizer) (Ambient Temperature $\leq$80°F):** The track may be put back at MAS provided that:

(i) The first train shall operate after out-of-face shoulder ballast cleaning at no more than 25F and 30P MPH.

(ii) The Operating Railroad person qualified under FRA §213.7 shall re-inspect the track and if no deficiencies are found; and

(iii) The track has a fully restored standard ballast section that has been treated with:

- A standard ballast compactor and/or;

- A dynamic stabilizer.

(iv) The track shall be returned to MAS.

(6) **Protective Slow Order (without compactor and/or stabilizer) (Ambient Temperature <u><</u>80°F):** If ballast compaction is not performed with a standard ballast compactor and/or a dynamic stabilizer:

(i) The track shall have a protective slow order of no more than 25F and 30P MPH for 24 hours. for a period of 24 hours ***<u>and</u>*** a minimum of 12 trains over the affected track.

(ii) The Operating Railroad person qualified under FRA §213.7 shall re-inspect the track and if no deficiencies are found;

(iii) The track speed shall be returned to MAS.

(7) **Protective Slow Order (with compactor and/or stabilizer) (Ambient >80°F):** In an emergency, if the ambient temperature exceeds 80°F (rail temperature >110°F), out-of-face shoulder ballast cleaning shall continue only if a shoulder compactor and/or dynamic stabilizer is used. A protective slow order shall be placed as follows:

(i) Wood or concrete tie track: not to exceed 25F and 30P MPH during the period the air temperature exceeds 80°F and/or until 24 hours elapses then re-inspect and return to MAS, if appropriate.

(j) **CWR Installation that is Unacceptable:**

(1) Fill out Track Disturbance Report (Form “TD”)

(2) CWR not installed in compliance with Section 3.0.

(3) A protective slow order not to exceed 25F and 30P MPH until the CWR is installed and adjusted to the target neutral temperature of 105°F as per Section 3.0.

(k) **Anchor or Clip Removal that Disturbs CWR Track:**

(1) When more than eight ties per 39’ of track have anchors or clips removed and/or missing; or,

(2) The required standard anchor pattern as in Section 4.0 does not exist, CWR track is disturbed; and

(3) Fill out Track Disturbance Report (Form “TD”)

(4) **Protective Slow Order (Ambient >80°F):** If anchor/clip replacement is not accomplished before the ambient temperature exceeds 80°F (rail temperature >110°F), a slow order not to exceed 25F and 30P MPH and shall be in effect until the proper number of anchors or clips are applied and/or re-applied in the pattern as described in Section 4.0.

(5) Install all missing anchors and/or clips.

(6) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(7) Following steps (3) through ((6), the track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

(l) **Cribbing that Disturbs CWR Track:**

(1) Cribbing more than three ties in a row in 39'; or

(2) Cribbing four or more ties with less than four undisturbed ties between ties cribbed.

(3) In all cases no more than three successive ties or more than four ties per 39’ of track can be cribbed in one pass.

(4) Track with the cribs reduced in the rail seat area for the mechanical installation of rail anchors on properly adjusted CWR does not require a slow order for improper ballast section, if this is the only ballast section deficiency and the track has not had lateral resistance reduced.

(5) If the ambient temperature is greater than 80°F (rail temperature greater than a neutral temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division.

(6) Fill out Form “TD” Track Disturbance Report.

(7) The track must be inspected by a person qualified under FRA §213.7 to ensure that the track is safe for the passage of the first train.

(8) Wood or concrete tie track will be returned to service:

  (i) When all the cribs are filled with new ballast and dressed and mechanically tamped.

(9) **Protective Slow Order (at any ambient temperature):** Not to exceed 25F and 30P MPH for a period of 24 hours and the passage of 12 trains over the affected track, re-inspect and return track to MAS, as appropriate.

(10) Following steps (6) through (9), track will be returned to MAS unless deficiencies or defects are observed and then appropriate remedial action shall be taken in accordance with FRA Part 213.

6.4 Suspension of Work Due to Heat Where Ambient Temperature >80°F or Rail Temperature >110°F

(a) The following work which can reduce the stability of CWR at higher temperatures will be suspended (except under a continuous track outage) or unless there is an emergency, when air temperatures are expected to be above 80ºF (rail temperature greater than a rail temperature of 110°F):

  (1) Tie Renewal

  (2) Tie Renewal in Curves

  (3) Surfacing, Smoothing and/or Lining

  (4) Out-of-face Curve Re-aligning

  (5) Cut and Throw of Track

  (6) Installation of Track or Switch Panels

  (7) Undercutting

  (8) Out-of-Face Shoulder Ballast Cleaning

  (9) Cribbing

6.5 Protection of Work Areas for Latent Heat Effects

(a) **This requirement applies for work that has been done that disturbs CWR track until seven days of traffic has been accumulated over the work area, or the period of high heat ends.**

(b) The speed restriction shall be placed by a person qualified on FRA §213.7(a)(b)(c), if appropriate, on a case-by-case basis if the air temperature is at 80ºF or above (rail temperature >110°F).

(c) Each Operating Railroad qualified employee in a work block is responsible for the protection and inspection requirements of this Section, as they relate to the work conducted under the railroad’s control.

(d) In the case where a Foreman is working in an out-of-service block of track under the control of another Foreman, but at a separate location from the Foreman providing protection:

(1) This Foreman will inspect and report the findings, if any, to the Foreman in charge of the track before reporting clear of the track.

(2) This report must include any required speed restrictions and any other information that would affect the safe movement of trains.

7.0 SPECIAL INSPECTIONS OF CWR TRACK

(a) **Special Inspection in Hot Weather**

(1) When the air temperature is ≥95ºF or the rail temperature is ≥125°F, all main tracks with CWR shall be inspected by qualified Operating Railroad personnel qualified on Track Safety Standards, Part 213, §213.7(a)(b)(c) and in accordance with currently established inspection procedures, outlined in this Appendix.

(2) During periods of extreme heat, when air temperatures exceed 95ºF or the rail temperature is ≥125°F, the Operating Railroad qualified employee should make Special Inspections and place appropriate speed restrictions (TSR) and take remedial action, as required.

(3) Determination of Temperature: The rail temperature is the preferred temperature and is taken with an approved rail thermometer. The air temperature is as reported by the National Weather Service.

(4) Operating Railroad personnel shall make out a “Special Track Inspection Report” (see Appendix F, “Forms”) for this inspection and retain a copy for the duration of the Operating Contract that can be reviewed by the MassDOT Rail and Transit Division.

(5) During this inspection, the track inspector must be particularly alert for wavy track, longitudinal rail movement, kinked joints in compression and evidence of lateral track movement. The track inspector must also be aware that the following conditions increase the possibility of buckling:

(i) Recently worked track

(ii) Fouled ballast and mud spots

(iii) Gaps in the ballast at the ends of the ties indicating tie movement

(iv) Existing deformations in line and surface

(v) Rail canting and/or lifting out of the tie plates

(vi) Shiny marks on the base of the rail indicating that the rail is sliding through the anchors and/or clips

(vii) Kinky or wavy rail

(viii) Bottom of sag curves

(ix) In areas of heavy braking and acceleration

(x) Higher degree curves

(xi) Fixed facilities (i.e., turnouts, road crossings, bridges, etc.)

(xii) Sub-standard ballast section

(xiii) Sub-standard anchor/clip pattern

(xiv) Sub-standard tie conditions

(6) If track is identified as having any conditions which indicate the possibility of buckling, remedial action must be taken immediately by Operating Railroad personnel qualified in FRA §213.7(a)(b)(c).

(b) **Special Inspection in Cold Weather**

(1) When the air temperature or the rail temperature is $\leq$10°F, all main CWR and jointed tracks will be inspected by qualified Operating Railroad personnel in accordance with currently established inspection procedures, outlined in this Appendix.

(2) Determination of Temperature: The rail temperature is the preferred temperature and is taken with an approved rail thermometer. The air temperature is as reported by the National Weather Service.

(3) Operating Railroad personnel shall make out a “Special Track Inspection Report” (see Appendix F, “Forms”) for this inspection and retain a copy for the duration of the Operating Contract that can be reviewed by the MassDOT Rail and Transit Division.

(4) Inspectors will inspect, at a minimum, for:

(i) Broken rails

(ii) Canted rails out of the plates on curves

(iii) Bent bolts

(iv) Pull-aparts

(v) Broken welds

(vi) Wide gap between rail ends

(vii) Cracked or broken joint bars (conventional and insulated)

(viii) Curve movement to the inside

(c) **Semi-Annual Inspections**

(1) A Spring inspection, between April 1 and May 30 (before air temperature of 80°F or a rail temperature of 110°F), and a Fall inspection between October 15 and November 15, shall be made by walking or by a hy-rail on all CWR main track. This inspection shall made using the “Report of Semi-Annual Inspection of CWR Track” found in Attachment E. The Inspection shall be made by a Manager of the Operating Railroad qualified under FRA §213.7(a)(b)(c).

(2) The inspection will concentrate on compliance with standards in the following areas:

(i) Anchor pattern

(ii) Anchor position

(iii) Resilient fasteners

(iv) Tie condition

(v) Ballast condition

(vi) Ballast section

(vii) Joint condition

(viii) Evidence of longitudinal rail movement, particularly at fixed locations, such as turnouts and grade crossings and open deck bridges.

(ix) Drainage condition

(x) Overall roadbed stability

(xi) Curve movement

(xii) Alinement deviations

(3) The Operating Railroad Manager will, within 30 days from the completion of the inspection, submit inspection information to the MassDOT Rail and Transit Division. Some of the information to be included is:

(i) A report of the special inspection that identifies track inspected by number and milepost limits;

(ii) The name of the individuals inspecting;

(iii) Date inspected;

(iv) Any exceptions found; and

(v) Protective and corrective action identified.

(d) **Protection of CWR Track with Deficiencies**

(1) When making Special Inspections (Hot and Cold Weather), Bi-Annual Inspections (Spring and Fall) and/or regular scheduled inspections in CWR track, if any of the above conditions described above in this paragraph are found to exist:

(i) Remedial action shall be taken, if required, as per FRA §213.5 by an individual qualified as per FRA §213.7(a)(b)(c).

(2) It is extremely important that noted deficiencies be corrected before the air temperature is expected to be above 80°F or the rail temperature expected to be above 110°F.

(3) If deficiencies are not corrected before the air temperature is expected to be above 80°F or the rail temperature above 110°F, appropriate remedial action shall be taken as per FRA§213.5, by an individual qualified as per FRA §215.7(a)(b)(c), if warranted.

(4) Determination of Temperature: The rail temperature is the preferred temperature and is taken with an approved rail thermometer. The air temperature is as reported by the National Weather Service.

8.0 JOINTS IN CWR TRACK

8.1 New Installations of CWR

(a) Joints in CWR track when installing CWR:

(1) When a joint or joints are installed in CWR during installation of CWR, one of the following actions per FRA 213.119(c)(2) shall be undertaken within 60 days:

(i) Weld the joint;

(ii) Install additional bolts in the joint bar so that all holes (6 holes) in the bar contain a bolt; or

(iii) Fully box anchor every tie for 195' in both directions from the joint.

8.2 Service Failures in Existing Previously Installed CWR

(a) Bolted joints in existing CWR that experience a service failure:

(1) In the case of a bolted joint in CWR experiencing service failure or a failed bar with a rail gap present, within 30 days either of the following actions per FRA 213.119(c)(3) shall be taken:

(i) Weld the joint;

(ii) Replace the broken bar(s), replace the broken bolts, adjust the anchors and, within 30 days, weld the joint;

(iii) Replace the broken bar(s), replace the broken bolts, install one additional bolt per rail end, and adjust anchors.

(iv) Replace the broken bar(s), replace the broken bolts, and anchor every tie 195' in both directions from the CWR joint; or

(v) Replace the broken bar(s), replace the broken bolts, add rail with provisions for later adjustment pursuant to FRA §213.119(d)(2) and reapply anchors.

8.3 Service Failure of Joint Bars and/or Track Bolts in a CWR Joint

(a) Minimum remedial action required:

(1) In the event of:

(i) Cracked or broken joint bar or bars, and

(ii) Bent and/or broken joint bolt or bolts,

(iii) Take the appropriate minimum remedial action given below and as shown in Attachment D, "Joint Defect Guidelines/Maximum Allowable Temporary Speed Restrictions (TSRs)".

(b) Number of bolts in rail ends required:

(1) In CWR track each rail end shall be bolted with at least two bolts at each bolted joint used to connect CWR strings, or CWR strings to conventional rail.

(2) Where either of the following conditions are found to exist, the track must be protected by the appropriate remedial action until the condition is corrected:

(i) Less than two bolts, but at least one bolt in a rail end: fix or place a TSR of no more than 10F/15P MPH until repaired.

(ii) One rail end unbolted (see Attachment D).

(3) Each joint bar must be held in position by track bolts or fasteners, and tightened sufficiently to provide support for abutting rail ends.

(4) When no-slip, or joint-to-joint rail contact exists by design; these locations are considered to be CWR track, and must meet all the requirements for CWR in this Appendix.

(c) Cracked or broken joint bars (see Attachment D):

(1) If a joint bar is cracked, broken or because of wear allows vertical movement of either rail when all bolts are tight, it shall be replaced.

(2) If a joint bar is cracked between the middle two bolt holes it shall be replaced.

(3) If between the middle two bolt holes, both joint bars are found to be cracked or one joint bar is found to be broken entirely through, trains may not be operated and the track taken out of service (see Attachment D) until the joint bars are replaced.

(4) If both joint bars are found to be broken entirely through between the middle two bolt holes, trains may not be operated and the track taken out of service (see Attachment D) until the joint bars are replaced.

(d) Opening (gap) of joints in CWR (see Attachment D):

(1) Bolted Rail Ends (Both Ends): The gap between rail ends shall be less than 1-1/2". If a joint is found to be open 1-1/2", a maximum 25F and 30P MPH temporary speed restriction shall be applied if there are two effective bolts in each rail end.

(2) Bolted Rail Ends (One End): If the gap between the rail ends is 1-1/2" but less than 2", a person designated under FRA §213.7(a)(b)(c)(d), shall visually supervise each train move. Repair the joint within 24 hours.

(3) Bolted Rail Ends (One End): If the gap between the rail ends is greater than 2" but 4" or less, a person designated under FRA §213.7(a)(b)(c)(d) shall visually supervise each train move. Repair the joint within 24 hours.

(4) Bolted Rail Ends (One End): If the gap between the rail ends is 4" or greater, the track shall be taken out of service until the joint is repaired.

8.4 Inspection of Joints In CWR Track

(a) Joints in CWR track must be inspected on foot according to §213.119. Rail joints in CWR track within turnouts, track crossings, expansion joints or lift rail assemblies need not be inspected during the walking inspection as they shall be inspected monthly in accordance with §213.235.

(b) The limits of the turnout for the purpose of this part are defined as a point 50 feet in advance of the points to the last long timber, or the heel of the frog if weave timbers are found at the heel.

(c) The limits of a track crossing, expansion joint, or lift rail assembly will be any joint within 20 ft. of the device.

(d) This inspection results shall be recorded on the Operating Railroad's Turnout Inspection Form.

(e) During walking inspections of joints in CWR particular attention must be paid to the following conditions of the joint and the track surrounding the joint:

   (1) Cracks in the joint bar

   (2) Evidence of movement of the bars in relation to the rail ends in the fishing areas ("loose" joints)

   (3) Loose, bent or missing joint bolts

   (4) Rail end batter

   (5) Rail end mismatch

   (6) Track surface, particularly hanging ties at the joint

   (7) Evidence of excessive longitudinal movement of rail noted by the displacement of rail anchors, or "polished" areas at the ends of the bars or at rail anchors or clips

(f) All requirements per FRA Part 213 applying to Gage, Track Surface, Crossties, Defective Rails, Rail End Mismatch, Rail Joints, Rail End Batter, Tie Plates, and Rail Fasteners still apply. If there is a combination of conditions that substantially increases the chance of a broken joint bar an appropriate speed restriction should be applied.

8.4.1 Embedded Joints

(a) Permanently Embedded Joints:

   (1) Where embedded joints exist, it is not necessary to disassemble or remove the track structure (e.g., remove pavement or crossing pads), to conduct an inspection of CWR joints unless there a deficiency or defect is suspected. Every effort must be made to inspect the visible portions of the joint bar and/or joint in embedded track construction.

   (2) In new construction there shall be no embedded joints without the permission of the MassDOT Rail and Transit Division.

(b) Temporarily Embedded Joints:

   (1) Joints may be embedded in a temporary crossing.

   (2) Every effort should be made to keep the joint bar visible for inspection through the use of flangeway protection such as timbers, etc.

8.4.2 Joint Inspection in CWR

(a) Each joint in CWR shall be identified by using:

(1) Route;

(2) Track designation;

(3) Milepost;

(4) Joint type;

(5) Rail designation; or

(6) Other information so that the joint can be identified in the field.

(b) The Operating Railroad Company will maintain a computer-based inventory of each joint and furnish a copy to MassDOT Rail and Transit Division annually. The annual report shall also include the past five years of data as developed by the Operating Railroad Company.

(c) Each time a joint is removed from track by welding and/or is removed by the installation of rail that eliminates the joint, a Report of Joint Elimination by Field Welding shall be filled out (see Attachment E). The disposition of joints in track removed shall be noted on the next report when inspecting joints in CWR. By doing this, joints in CWR are reported from the time they are introduced until the time they are removed from track.

(d) The joint inventory will not contain those joints considered part of a turnout, track crossing, expansion joint, or lift rail assembly as the inspection of these joints is contained on the Monthly Switch Inspection Form as per §213.235.

8.4.3 Record of Inspections

(a) Each walking inspection of a joint in CWR track shall be recorded on the Operating Railroad Company's Special Track Inspection Report.

(b) The information on the Form shall include at a minimum, the Joint Identification Number, the route, the track, the milepost, the rail type, and any defects that require a remedial action and/or a permanent repair.

9.0 TRAINING

(a) To be considered qualified under §213.7 to supervise or conduct the installation, maintenance, adjustment and inspection of CWR track; individuals will receive instruction in, and be tested on, the **Operating Railroad's Approved CWR Plan.**

(b) All Operating Railroad MW employees responsible for the inspection, installation, adjustment, or maintenance of CWR track must successfully complete training on the Operating Railroad's Approved CWR Plan every calendar year.

(c) In addition, Operating Railroad MW employees shall be provided with a copy of these procedures which they shall make available at any CWR job site, if requested.

(d) The Operating Railroad shall maintain a list of those employees qualified to supervise restorations and inspect track in CWR territory. The Operating Railroad shall make this list available upon request.

(e) Annual CWR training programs will address the following:

(i) The Operating Railroad's Approved CWR Plan and the application of written CWR procedures issued by the Operating Railroad.

(ii) The qualification and designation of the Operating Railroad's MW personnel to:

- Know and understand the requirements of the Operating Railroad's CWR Plan; and
- Have the ability to detect deviations from the Operating Railroad's CWR Plan; and

- Can prescribe appropriate remedial action when deviations are discovered from the Operating Railroad's CWR Plan; and
- Have written authorization from the Operating Railroad to prescribe remedial action and/or make necessary repairs.

(iii) Subjects to be discussed during the annual training on the Operating Railroad's CWR Plan include, but are not limited to, the following:

- Installation and Adjustment of CWR
- Anchoring of CWR
- Maintenance of Desired Rail Neutral Temperature in Previously Installed CWR
- Trackwork That Disturbs CWR Track and Protection of Disturbed Track
- Special Inspections of CWR Track
- Joint Inspections in CWR Track
- Training
- Record Keeping

10.0 REPORTING REQUIREMENTS FOR CWR TRACK

(a) **Report of Disturbance of CWR Track (Form "TD") (Attachment E)**

(1) When any maintenance operations are considered to have disturbed CWR track as per Section 6.0, or if any rail is cut in CWR track or a service failure occurs in CWR track, a "Report of Track Disturbance", Form "TD", will be filled out by the Operating Railroad.

(i) Part A of this Form shall be completed for any work listed in Section 6.0 above which causes the CWR track to be considered disturbed.

(ii) Part B shall be completed whenever there is a Service Failure or CWR in main track is cut or broken for any reason.

(iii) The "Report of Track Disturbance Form" with instructions is found in Attachment E.

(iv) When this report is completed, a copy shall be retained on file for the duration of the Operating Contract for review by the MassDOT Rail and Transit Division.

(b) **Report of Track Movement (Form "TM") (Attachment E)**

(1) During out-of-face surfacing operations and/or the out-of-face installation of ties, the neutral temperature can be adversely affected on curved track. The track may be line in and/or the track may pull in due to reduced longitudinal and lateral resistance of the track structure.

(i) For curves of 3° and greater, a "Report of Track Movement, Form "TM" shall be made out when the curve is surfaced out-of-face or when more than 540 ties per mile are installed.

(ii) This report shall be required in addition to the Report of Track Disturbance of CWR Track (Form "TD").

(iii) The curve shall be stationed at key geometric locations. Reference stakes shall be added to the field side of the high side of the curve so that curve movement during and/or after maintenance work is performed can be obtained.

(iv) This report shall be completed by the Contractor or Operating Railroad Company on whose territory the work is being performed. The "Report of Track Movement" Form with instructions is found in Attachment E.

(v) When this report is completed, a copy shall be retained on file for the duration of the Operating Contract for review by the Operating Railroad Company.

(c) **Report of Joint Elimination by Field Welding (Form "JE") (Attachment E)**

(1) Any time a field weld is made to eliminate a joint, either by the thermite or flash butt method, Form "JE" must be completed by the Contractor/Operating Railroad Company in charge of the work.

(i) The "Report of Joint Elimination by Field Welding" is found in Attachment E.

(ii) This report shall be required in addition to the Report of Track Disturbance of CWR Track (Form "TD").

(iii) This report shall be completed by the Contractor/Operating Railroad Company on whose territory the work is being performed.

(iv) When this report is completed, a copy shall be retained on file for the duration of the Operating Contract for review by the Mass DOT Rail and Transit Division.

(d) **Report of Rail Clipping/Anchoring (Form "RC") (Attachment E)**

(1) Any time CWR is adjusted according to the requirements of Section 3.0 of this document the Form, "Record of Rail Clipping/Anchoring," Form "RC," must be completed by the Contractor/Operating Railroad Company in charge of the work.

(i) The "Record of Rail Clipping/Anchoring", Form "RC" with instructions, is found in Attachment E.

(ii) When this report is completed, a copy shall be retained on file for the duration of the Operating Contract for review by the Operating Railroad Company.

(e) **Report of Semi-Annual (Spring/Fall) Inspection of CWR Track (Form "CWR") (Attachment E)**

(1) Any time CWR is inspected annually either in the Spring and/or the Fall according to the requirements of Section 7.0 of this document the Form, **"**Report of Semi-Annual (Spring/Fall) Inspection of CWR Track," Form "CWR" must be completed by the Contractor/Operating Railroad Company in charge of the work.

(i) The **"**Report of Semi-Annual (Spring/Fall) Inspection of CWR Track," Form "CWR", is found in Attachment E.

(ii) When this report is completed, a copy shall be retained on file for the duration of the Operating Contract for review by the Operating Railroad Company.

(f) **Special Inspections – Earthquakes**

(1) When an earthquake occurs, each quake's magnitude – or inherent strength is measured and reported by the National Earthquake Information Service operated by the U.S. Geological Survey in Golden, Colorado.

(2) The Richter scale gages the energy released by an earthquake, as measured by the ground motion recorded on a seismograph. The magnitude of an earthquake is the same no matter where one is located. Its intensity – or the degree to which it is felt in a specific location – varies depending on one's distance from the earthquake's epicenter, or center of energy.

(3) When an earthquake is reported, the Operating Railroad notifies Maintenance-of-Way to begin a Special Track Inspection.

(4) Use the criteria in the Table below to determine whether a special inspection is warranted.

Magnitude (Richter Scale)	Initiate Special Track Inspection	Criteria/Action
Unknown	Yes	Reports of ground shaking in a geographic area. Trains stop within 50-mile radius of reported shaking until inspection is complete.
0.1 to 4.9	No	No action required.
5.0 to 5.4	Yes	When track is within a 30-mile radius of the epicenter, trains in affected areas slow to restricted speed until inspection is complete.
5.5 to 5.9	Yes	When track is within a 50-mile radius of the epicenter, trains stop in the affected area until inspection is complete.
6.0 to 6.9	Yes	When track is within a 100-mile radius of the epicenter, trains stop in the affected area until inspection is complete.
7.0 and above	Yes	When track is within a 150-mile radius of the epicenter, trains stop in the affected area until inspection is complete.

(5) Special inspections shall identify hazards and identify necessary remedial action(s) to protect the safety of trains operating in the affected areas.

(6) When conducting a special inspection, check the following:

- Materials fouling the track, such as trees, pole lines, wires, etc.
- Alignment, cross level, and profile of the track.
- Bridge piers, abutments, and bulkheads for signs of structural damage.
- Substructure and superstructure for damage from large objects falling into structures.
- Piers, bents, and bridge members for missing components.
- Signal outages and malfunctions.
- Landslides in cuts and slope failures in fills.

(7) Fill out “Special Track Inspection Report” and retain for duration of Operating Contract.

11.0 RECORD KEEPING

(a) **Report of CWR Installations**

(1) Rail temperature, neutral temperature, location, and date of CWR installations must be recorded in system logs or data management system and must be retained by the Operating Railroad for the duration of the Contract with the MassDOT Rail and Transit Division.

(b) **Report of Maintenance Work in CWR**

(1) Because track maintenance can substantially impact CWR stability and safety, the following records of work done must be recorded on Form “TD” and must be kept by the Operating Railroad for the duration of the Contract with the MassDOT Rail and Transit Division.

(i) Rail that is added for any reason.

(ii) Repair of broken or defective rails, pull-aparts and welding of rail joints, and changing glued plug insulated joints.

(iii) A record of pre-break/cut RNT when rail has pulled apart, broken, or been cut for defect removal (see Attachment C).

(iv) A record of the readjusted RNT after a rail has pulled apart, broken, or been cut for defect removal (see Attachment C).

(v) Where a curve has been staked and the curve has chorded as a result of surfacing and lining track (Form “TM”, Attachment E).

(vi) CWR installation or maintenance work that does not conform to Appendix “A” procedures.

(2) Any time work is performed in CWR territory by a Contractor and/or the Operating Railroad, an Operating Railroad qualified person under FRA §213.7(c) shall make out a Track Disturbance Form (Form “TD”, Attachment E).

(3) The Contractor and/or the Operating Railroad shall review the Form “TD” to ensure necessary corrections and adjustments and permanent repairs are made so as to maintain the overall stability of CWR track.

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ATTACHMENT A

DETERMINATION OF ESTIMATE OF PRE-BREAK / PRE-CUT NEUTRAL TEMPERATURE FOR A SERVICE FAILURE IN CWR

(a) General

(1) In line with Section 5.0's requirements, the RNT will be estimated and recorded on Form "TD" where a weld has broken or a rail has pulled apart, broken or been cut for defect removal (service failure).

(2) This attachment addresses how to calculate the rail's neutral temperature before the break or before the cut for defect removal.

(3) Attachment A provides an estimate of neutral temperature based on the measured field gap size, rail size and fastener type.

(4) The rail size is given in terms of a 6" base rail (i.e., for rail sizes above 115# rails) and for 5-1/2" rail (i.e., for 115# and below).

(5) The fastener types are given as EOTA (every other tie anchored) and ETA (every tie anchored).

(6) Concrete tie elastic fasteners, CTEF, and elastic fasteners on wood ties (such as Pandrol type) fall into the ETA category.

(7) The pre-break/pre-cut estimated RNT must be recorded on Form "TD" when making field repairs and kept in a data base by the Operating Railroad for managing subsequent readjustments.

(b) Use of the following tables: **NOTE**

(1) For wood tie tracks 200' from a fixed point (switches, turnouts, crossings, bridges, tunnels, etc.) they **DO NOT apply**. For such the data entry on the Form "TD" should be: ***NA**.

(2) For wood tie tracks between 200' - 400' of a fixed point apply EOTA tables, but data entry Form "TD" should be: ***AP** (for approximate)

(3) Tables for concrete ties and for wood ties with elastic fasteners, apply 200' beyond a fixed point, but **DO NOT apply within 200'**. For the latter, data entry on Form "TD" should be: ***NA**.

(4) For wood or concrete tie tracks where breaks/cuts on the same rail are clustered in close proximity (i.e., within 800' of each other). The data entry on Form "TD" should be: ***NA**.

(5) For iced rail/frozen ballast, tables **DO NOT apply**. For such, data entry on Form "TD" should indicate: ***FB**.

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Table 1a. 6" Base Rail
Wood Tie Track / Every Other Tie Anchored (EOTA)

Field Measured Rail Break/Rail Cut Temp (°F)	Measured Rail Gap (in)																	
	0.5	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**
60	84	94	102	109	114	119	124	129	133	137	140	144	147	151	154			
55	79	89	97	104	109	114	119	124	128	132	135	139	142	146	149	152		
50	74	84	92	99	104	109	114	119	123	127	130	134	137	141	144	147	150	153
45	69	79	87	94	99	104	109	114	118	122	125	129	132	136	139	142	145	148
40	64	74	82	89	94	99	104	109	113	117	120	124	127	131	134	137	140	143
35	59	69	77	84	89	94	99	104	108	112	115	119	122	126	129	132	135	138
30	54	64	72	79	84	89	94	99	103	107	110	114	117	121	124	127	130	133
25	49	59	67	74	79	84	89	94	98	102	105	109	112	116	119	122	125	128
20	44	54	62	69	74	79	84	89	93	97	100	104	107	111	114	117	120	123
15	39	49	57	6	69	74	79	84	88	92	95	99	102	106	109	112	115	118
10	34	44	52	59	64	69	74	79	83	87	90	94	97	101	104	107	110	113
5	29	39	47	54	59	64	69	74	78	82	85	89	92	96	99	102	105	108
0	24	34	42	49	54	59	64	69	73	77	80	84	87	91	94	97	100	103
-5	19	29	37	44	49	54	59	64	68	72	75	79	82	86	89	92	95	98
-10	14	24	32	39	44	49	54	59	63	67	70	74	77	81	84	87	90	93
-15	9	19	27	34	39	44	49	54	58	62	65	69	72	76	79	82	85	88
-20	4	14	22	29	34	39	44	49	53	57	60	64	67	71	74	77	80	83
-25	-1	9	17	24	29	34	39	44	48	52	55	59	62	66	69	72	75	78
-30	-6	4	12	19	24	29	34	39	43	47	50	54	57	61	64	67	70	73
-35	-11	-1	7	14	19	24	29	34	38	42	45	49	52	56	59	62	65	68
-40	-15	-6	2	9	14	19	24	29	33	37	40	44	47	51	54	57	60	63
-45	-21	-11	-3	4	9	14	19	24	28	32	35	39	42	46	49	52	55	58
Estimated RNT in °F																		

Note: For rail temperatures above 60°F, the estimated RNTs must be developed by interpolating the existing table.

Table 1b. 5-1/2" Base Rail
Wood Tie Track / Every Other Tie Anchored (EOTA)

Field Measured Rail Break/Rail Cut Temp (°F)	**Measured Rail Gap (in)**																	
	0.5	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**
60	86	97	106	113	119	125	130	135	139	144	148	152	155					
55	81	92	101	108	114	120	125	130	134	139	143	147	150	154				
50	76	87	96	103	109	115	120	125	129	134	138	142	145	149	153			
45	71	82	91	98	104	110	115	120	124	129	133	137	140	144	148	151		
40	66	77	86	93	99	105	110	115	119	124	128	132	135	139	143	146	149	152
35	61	72	81	88	94	100	105	110	114	119	123	127	130	134	138	141	144	147
30	56	67	76	83	89	95	100	105	109	114	118	122	125	129	133	136	139	142
25	51	62	71	78	84	90	95	100	104	109	113	117	120	124	128	131	134	137
20	46	57	66	73	79	85	90	95	99	104	108	112	115	119	123	126	129	132
15	41	52	61	68	74	80	85	90	94	99	103	107	110	114	118	121	124	127
10	36	47	56	63	69	75	80	85	89	94	98	102	105	109	113	116	119	122
5	31	42	51	58	64	70	75	80	84	89	93	97	100	104	108	111	114	117
0	26	37	46	53	59	65	70	75	79	84	88	92	95	99	103	106	109	112
-5	21	32	41	48	54	60	65	70	74	79	83	87	90	94	98	101	104	107
-10	16	27	36	43	49	55	60	65	69	74	78	82	85	89	93	96	99	102
-15	11	22	31	38	44	50	55	60	64	69	73	77	80	84	88	91	94	97
-20	6	17	26	33	39	45	50	55	59	64	68	72	75	79	83	86	89	92
-25	1	12	21	28	34	40	45	50	54	59	63	67	70	74	78	81	84	87
-30	-4	7	16	23	29	35	40	45	49	54	58	62	65	69	73	76	79	82
-35	-9	2	11	18	24	30	35	40	44	49	53	57	60	64	68	71	74	77
-40	-14	-3	6	13	19	25	30	35	39	44	48	52	55	59	63	66	69	72
-45	-19	-8	1	8	14	20	25	30	34	39	43	47	50	54	58	61	64	67
Estimated RNT in °F																		

Note: For rail temperatures above 60°F, the estimated RNTs must be developed by interpolating the existing table.

Table 2a. 6" Base Rail
Wood or Concrete Tie Track / Every Tie Anchored (ETA)

Field Measured Rail Break/Rail Cut Temp (°F)	Measured Rail Gap (in)																	
	0.5	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**
60	90	102	111	119	126	133	139	144	149	154	159							
55	85	97	106	114	121	128	134	139	144	149	154	158						
50	80	92	101	109	116	123	129	134	139	144	149	153	157					
45	75	87	96	104	111	118	124	129	134	139	144	148	152	156				
40	70	82	91	99	106	113	119	124	129	134	139	143	147	151	155			
35	65	77	86	94	101	108	114	119	124	129	134	138	142	146	150	154		
30	60	72	81	89	96	103	109	114	119	124	129	133	137	141	145	149	153	
25	55	67	76	84	91	98	104	109	114	119	124	128	132	136	140	144	148	151
20	50	62	71	79	86	93	99	104	109	114	119	123	127	131	135	139	143	146
15	45	57	66	74	81	88	94	99	104	109	114	118	122	126	130	134	138	141
10	40	52	61	69	76	83	89	94	99	104	109	113	117	121	125	129	133	136
5	35	47	56	64	71	78	84	89	94	99	104	108	112	116	120	124	128	131
0	30	42	51	59	66	73	79	84	89	94	99	103	107	111	115	119	123	126
-5	25	37	46	54	61	68	74	79	84	89	94	98	102	106	110	114	118	121
-10	20	32	41	49	56	63	69	74	79	84	89	93	97	101	105	109	113	116
-15	15	27	36	44	51	58	64	69	74	79	84	88	92	96	100	104	108	111
-20	10	22	31	39	46	53	59	64	69	74	79	83	87	91	95	99	103	106
-25	5	17	26	34	41	48	54	59	64	69	74	78	82	86	90	94	98	101
-30	0	12	21	29	36	43	49	54	59	64	69	73	77	81	85	89	93	96
-35	-5	7	16	24	31	38	44	49	54	59	64	68	72	76	80	84	88	91
-40	-10	2	11	19	26	33	39	44	49	54	59	63	67	71	75	79	83	86
-45	-15	-3	6	14	21	28	34	39	44	49	54	58	62	66	70	74	78	81
Estimated RNT in °F																		

Note: For rail temperatures above 60°F, the estimated RNTs must be developed by interpolating the existing table.

Table 2b. 5-1/2" Base Rail
Wood or Concrete Tie Track / Every Tie Anchored (ETA)

Field Measured Rail Break/Rail Cut Temp (°F)	**Measured Rail Gap (in)**																	
	0.5	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**
60	92	106	116	125	133	139	146	152										
55	87	101	111	120	128	134	141	147	152									
50	82	96	106	115	123	129	136	142	147	153								
45	77	91	101	110	118	124	131	137	142	148	153							
40	72	86	96	105	113	119	126	132	137	143	148	152						
35	67	81	91	100	108	114	121	127	132	138	143	147	152					
30	62	76	86	95	103	109	116	122	127	133	138	142	147	151				
25	57	71	81	90	98	104	111	117	122	128	133	137	142	146	151			
20	52	66	76	85	93	99	106	112	117	123	128	132	137	141	146	150		
15	47	61	71	80	88	94	101	107	112	118	123	127	132	136	141	145	149	153
10	42	56	66	75	83	89	96	102	107	113	118	122	127	131	136	140	144	148
5	37	51	61	70	78	84	91	97	102	108	113	117	122	126	131	135	139	143
0	32	46	56	65	73	79	86	92	97	103	108	112	117	121	126	130	134	138
-5	27	41	51	60	68	74	81	87	92	98	103	107	112	116	121	125	129	133
-10	22	36	46	55	63	69	76	82	87	93	98	102	107	111	116	120	124	128
-15	17	31	41	50	58	64	71	77	82	88	93	97	102	106	111	115	119	123
-20	12	26	36	45	53	59	66	72	77	83	88	92	97	101	106	110	114	118
-25	7	21	31	40	48	54	61	67	72	78	83	87	92	96	101	105	109	113
-30	2	16	26	35	43	49	56	62	67	73	78	82	87	91	96	100	104	108
-35	-3	11	21	30	38	44	51	57	62	68	73	77	82	86	91	95	99	103
-40	-8	6	16	25	33	39	46	52	57	63	68	72	77	81	86	90	94	98
-45	-13	1	11	20	28	34	41	47	52	58	63	67	72	76	81	85	89	93
Estimated RNT in °F																		

Note: For rail temperatures above 60°F, the estimated RNTs must be developed by interpolating the existing table.

ATTACHMENT B

RECOMMENDED PROCEDURES FOR DISTRESSING CONTINUOUS WELDED RAIL (CWR) PREVIOUSLY LAID IN TRACK (IN CONFORMANCE WITH SECTION 5.0 REQUIREMENTS)

(a) MassDOT's CWR Policy prescribes distressing requirements for newly installed CWR as per Section 3.0, including a general procedure for distressing rail.

(1) **Attachment B provides more detailed Recommended Procedures for distressing CWR previously laid in track based on current industry best practice guidelines.**

(b) **Definition**: Distressing is the operation of removing (or sometimes adding) rail in CWR to make the longitudinal thermal stress (force) to be zero at a prescribed temperature.

(1) MassDOT's preferred Rail Laying Temperature (RLT) is 105°F.

(c) **Common Distressing Types for Existing CWR in Track:**

(1) There are typically three types, or categories, of distressing which are driven by specific maintenance needs:

(i) **programmed distressing**,

(ii) **reactive or emergency distressing**, and

(iii) **curve distressing**. (Note: although curve distressing can be both programmed and reactive, a separate category is given here due to its general complexity).

(2) **Programmed distressing** is when one or more strings of rail are deemed to be sufficiently below (or above) RLT to warrant rail neutral temperature (RNT) adjustment. When several strings require distressing on MassDOT-owned rail lines, often the out-of-face distressing shall be accomplished by a Contractor working directly for MassDOT Rail and Transit.

(3) **Reactive or emergency distressing** is an imminent action that addresses tight, wavy, kinky rail, and other buckling prone conditions. This type of work on MassDOT-owned rail lines is usually accomplished by the Operating Railroad Personnel.

(4) **Curve distressing** applies to stress adjustments of curves due to cold temperature chording-in or to excessive curve movements resulting from maintenance actions performed when rail is in tension. This type of work on MassDOT-owned rail lines is usually accomplished by Operating Railroad Personnel or by a Contractor working directly for MassDOT Rail and Transit.

(d) **General Guidelines for Programmed Distressing of CWR Strings In Track Up to 1600' In Length.**

(1) **Programmed Distressing may be used for:**

(i) Rail that was laid at colder temperatures sufficiently below a target RNT of 105°F; or

(ii) Rail laid at "hot" temperatures, which exhibits excessive rail movement (running rail); or

(iii) Locations where recent track maintenance (lining, surfacing, lifting, etc.) has lowered RNT below RLT -10°F or 95°F; or

(iv) Locations where the Operating Railroad and/or MassDOT Rail and Transit Division deems it necessary.

(2) The following applies when distressing:

(i) The means, methods, and equipment used when distressing rail shall be approved by MassDOT Rail and Transit or its representative.

(ii) The range of rail temperature at which rail is distressed shall be approved by MassDOT Rail and Transit or its representative.

(iii) Distressing should be scheduled and completed when the ambient temperature provides sufficient heat so that the rail temperature is as near as possible to the target RLT of 105°F; unless approved by MassDOT Rail and Transit.

(iv) **No more than 1,600' of rail may be distressed at any given time (1,600' strings).** This is a continuous 1600' string and/or a 1600' string with a cut or joint in the middle (800'+/- each side of cut and/or joint).

(3) The following preparatory work shall be performed:

(i) Make reference match marks around the existing joint or rail cut location:

- On the base of rail and tie plates on unanchored ties within 10'+/- of the joint and/or cut in the rail; or
- On the left side of the elastic fastener tie plate or the side opposite the drive on elastic fastener or clip within 10'+/- of the joint and/or cut in the rail; and

(ii) When distressing one or more strings, mark the quarter points of the string to be distressed.

(iii) When out-of-face distressing, set offset stakes at the far end of the rail to be distressed to measure any rail panel “pull” back at the end of the CWR string where the rail is cut and/or a joint is located.

(iv) Rail panel “pull back” is often associated with wood tie track anchored on every tie with elastic fasteners or in areas with weak crib ballast.

(v) Rail panel “pull back” movements (inches) shall be measured after:

- The rail has been correctly expanded at the quarter points and at the end by using the ambient temperature, a rail heater and/or a. hydraulic rail puller, and;
- The CWR string has been anchored and/or clipped.

(vi) Rail panel “pull back” measured is the same as ADDING RAIL and the CWR shall have to be unclipped and expanded again to eliminate any pull back when it is finally anchored and clipped before it is finally jointed and/or welded.

(vii) Measured rail end movements away from the joint or cut at the end of the CWR string at the match marks is the same as ADDING RAIL. The CWR shall have to be unclipped and expanded again to eliminate any rail end movement away from the joint and/or cut before the CWR is finally jointed and/or welded.

(viii) The total expansion length required, using the temperature differential, shall be calculated so as to achieve a target RLT of at least 105°F.

(ix) The amount of rail to be expanded when using the temperature differential moved can be determined by using the Report of Rail Clipping/Anchoring, Form “RC” found in Attachment E.

(x) To improve RNT, the total required expansion for any string, shall consist of the following:

- The calculated expansion required from the temperature "differential", and;
- Any measured "rail panel pull back", and;
- Any measured rail end movements away from the joint and/or cut.

(xi) If in compression, the rail shall be cut with a torch (see Paragraph (g) below) and placed in a position that will permit the rail ends to bypass each other, so as to permit the rail to expand freely.

(xii) If in compression, the rail shall be unanchored or unclipped from the cut or joint at the end of the string to be expanded back to the beginning of the string.

(xiii) If the base of rail is caught in the elastic rail fastener plates, the rail shall be raised from the tie plates or tie pads. Place base of rail on risers (spikes and/or rollers) to allow the rail to expand freely; risers shall be placed every 12^{th} to 15^{th} tie (especially in areas of elastic fastener plates). There may be a need to add additional risers at closer intervals on curves.

(xiv) If risers are required, all rail anchors, clips and insulators must be removed and risers placed to ensure the base of the rail is free to move relative to the tie plate and/or tie seat (i.e., stress free).

(xv) If power vibrators are used, it may not be necessary to place the rail on risers in areas of cut spikes and conventional tie plates.

(xvi) Ensure that vibrated rail is totally free to expand/contract longitudinally (i.e., stress free).

(e) **Programmed Distressing: Adjusting Short CWR Lengths (Spot Distressing) Already in Track in Wood and Concrete Tie Territory)**

(1) This method is generally used by the Operating Railroad MW forces to repair a service failure such as a pull-apart, broken rail, or broken weld and to remove a defective rail and/or add a plug rail or by making a cut in CWR.

(2) When distressing short lengths Operating Railroad MW forces generally use the ambient temperature and/or a rail puller to obtain the expansion required.

(3) In this case, the rail to be distressed should be centered, if possible, on an existing joint that can be removed and/or a cut made in the CWR string. Approximately 50% of the area to be distressed should be on either side of the joint and/or cut.

(4) In this case, the rail on either side of the joint and/or cut is expanded towards the rail cut and/or joint location.

(5) The base of the rail and plate should be marked at or within 10' of either side of the joint or cut and then at 50' stations or the quarter points for the full length of the rail to be expanded.

(6) Generally the amount of rail to be expanded on either side of the joint and/or cut is from 195' (380' total) to 390' (780' total). However, longer lengths of CWR, up to 800' (1600' total) may be distressed by this method.

(7) The movement at these stations should be recorded when the joint is removed and/or the rail is cut and recorded on Form "TD."

(8) A rail puller can be used, along with the ambient temperature and/or a heater, to increase the RNT, to at least **RLT -10°F**, when making repairs.

(9) Because of the need to expand rail in two directions, it may be somewhat easier to achieve the required expansion by using the ambient temperature in warmer periods of the year and/or by using a rail puller. A rail heater is more problematic because of the need to have the heater working on both sides of the joint and/or cut and having to move the heater over the joint or cut to expand rail in two directions.

(10) See Attachment C "Recommended Procedures for Adjusting CWR After a Break (Service Failure) or Cut Below the Target RLT (105°F)."

(f) **Programmed Distressing: Adjusting Numerous CWR Strings Out-of-Face Already in Track in Wood and Concrete Tie Territory (Preferred Method)**

(1) This procedure applies to distressing CWR in track as part of programmed maintenance when a length of rail(s) is deemed to be sufficiently below (or above) the target RLT of105°F to warrant RNT readjustment.

(2) The preferred way to expand rail is to heat the rail naturally or with a rail heater. A rail puller may be used when expanding rail to help achieve the required expansion and/or hold the expanded rail in place while installing anchors and/or clips.

(3) The rail to be distressed is usually expanded from the starting point to the end of the string being distressed in one continuous direction.

(4) The maximum length of rail to be distressed at any time in 1600'.

(i) Once a string to be distressed is identified, the end of the string at an existing joint, or a location where the rail is cut, shall have the rail ends mismatched to allow unobstructed movement of the rail string. Then, as the rail is heated naturally by sunlight and/or with a rail heater, the rail is expanded in the direction towards the joint and/or cut.

(ii) Before expanding the rail string, anchors, and/or clips shall be removed starting at the far end of the string at the joint and/or rail cut back to the beginning of the rail string.

(iii) Measure the existing rail temperature and subtract from the target RLT of at least 105°F to determine the temperature differential to be used. See the Report of Rail Clipping/Anchoring (Form "RC") in Attachment E to calculate the total expansion required. The expansion required depends upon the rail temperature differential and total length of the CWR string. The required amount of expansion shall be marked at the one-quarter points on the base of the rail and plates.

(iv) Mark the quarter points on the base of the rail and tie plates of rail strings to be expanded.

(v) Expanding rail continuously in one direction allows MW crews to mark and expand rail at the quarter points and then re-clip rail in a continuous motion from the point of beginning to the end of the string at the joint and/or cut in the CWR.

(vi) Heat (natural or with a rail heater) should be uniformly applied along the string to be distressed until the required expansion has been obtained at the quarter points to include the end of the string at the joint and/or cut rail.

(vii) When using a rail heater, if any quarter point does not have the required expansion, either before or after anchoring/clipping, the string shall have to be reheated. The rail heater will back over the portion that needs to be reheated without applying heat.

(viii) Then the heater shall work towards the end of the string at the joint or rail cut applying heat until the required expansion is obtained.

(ix) Re-clip and/or re-anchor the rail as soon as expansion at the quarter points has been achieved. Clip and/or anchor using the standard anchor patterns given in Section 4.0 “Anchoring of Rail.”

(x) The CWR shall not be considered to be distressed until the required expansion at all the quarter points have been realized. When distressing strings of CWR, rail expansion, and not rail temperature, determines if a string of CWR has been distressed.

(xi) A rail puller can be used to hold the required expansion and/or to help get the required expansion. At least 20 ties on the next string to be distressed should be solid box anchored and/or clipped to provide sufficient holing power for the rail puller to hold or pull the string being expanded.

(g) **Torch Cutting CWR in Track**

(1) The preferred method of cutting CWR in compression is with a torch.

(2) Rail shall only be torch cut in an emergency to relieve thermal stress in the rail prior to expanding and then cutting with a rail saw.

(3) Operating Railroad personnel and/or Contractors shall be trained to cut rail with a torch in accordance with their in-house Safety Procedures.

(4) Operating Railroad personnel and/or Contractors shall not cut rail with a torch on MassDOT property unless trained to do so by their respective companies.

(5) A recommended procedure for torch cutting rail in compression is illustrated in Attachment F “Torch Cutting Rail.”

(6) Person making torch cut:

(i) Shall stand on opposite side of rail from which it is expected to move when making torch cut.

(ii) In curve if buckle/alignment is on high side of curve; stand on low side of curve.

(iii) In tangent track, stand on side opposite from misalignment or buckle.

(7) Initially, remove anchors only in an area large enough to facilitate the torch cut. Do not remove any additional anchors until the torch cut is made.

(8) Clear personnel from misalignment area when rail is cut as rail/track may move suddenly when compressive stress is relieved by torch cutting.

(9) Additional anchors shall be removed after the rail is torch cut to facilitate the necessary rail expansion movement, the misalignment of rail ends and repair.

(10) If a torch cut rail is to be welded within 15 minutes of cutting, it shall be trimmed back at least 3/8" on each rail end with a saw before welding. **This practice requires the approval of the local MassDOT Rail and Transit Field Representative.**

(11) All torch cut rail ends shall be trimmed back:

(i) At least 2" (AREMA Chapter 4.7.3) and/or;

(ii) Beyond the heat affected zone on either side of the torch cut which will appear as a different color on the web of the rail; or whichever is greater;

(iii) With a rail saw before a field weld is made and/or a joint is applied.

(12) If necessary, in an emergency, to pass a train over a torch cut rail end, before the torch cut ends are trimmed back:

(i) Joint bars may be installed with at least two bolts in each rail end, if possible.

(ii) Each train may be passed over the joint at a maximum of 10F/15P provided the move is under the supervision of a qualified person under FRA §213.217(a)(b)(c)(d).

(h) **Reactive or Emergency Distressing: Cutting Tight Track/CWR in Compression**

(1) If a misalignment (wavy, kinky or nervous rail) is found in track that exceeds values for any class of track found in FRA §213.55, Alinement, take appropriate remedial action per FRA §213.9.

(2) Locate point of maximum misalignment.

(3) Fill out Form “TD” and include rail temperature and alinement deviation/defect as per FRA §213.55.

(4) Select a point to make a torch cut. It may be advisable to cut at a point near, but not exactly at the center of the misalignment where compressive stresses may be the highest.

(5) A recommended procedure for torch cutting rail in compression is illustrated in Attachment F “Torch Cutting Rail.” See additional torch cutting information found in (g).

(6) Make repairs in accordance with, “Reactive or Emergency Distressing” (see Example 3).

(i) **Reactive Distressing: Adjusting Tight, Wavy Nervous Rail: Procedures**

(1) Reactive distressing consists of actions taken to address tight, wavy, kinky rail conditions seen in CWR track. Usually tight, wavy, or nervous rail is discovered when the rail temperatures are warm.

(2) Such conditions typically are associated with large reductions in rail temperatures and indicate a possible imminent track buckle.

(3) First establish the length of rail exhibiting the tight, wavy condition (i.e., the length of rail requiring neutral temperature adjustment through distressing).

(4) **The total length for distressing is a recommended minimum of 1.5 times the estimated tight, wavy length (although 2 times is the MassDOT preferred).**

(5) **Note: 400' of unfastening (200' either side of torch cut) is a *minimum* distance.** More length is required if the estimated $L_{distress}$ is longer than **260'**, in which case the unfastening length rule of thumb is:

$$\textbf{Unfastening Length} = \mathbf{1.5 \times L_{distress}}$$

(6) Generally *both* rails should be distressed unless otherwise dictated.

(7) The procedure to follow is as described below.

(i) Estimate the length of the tight, kink, wavy rail segment; locate the midpoint where rail is to be cut.

(ii) Record the length of rail to be distressed (i.e., $L_{distress}$ = _____ ft.).

(iii) Cut rail. (**Note: typically torch cutting is required)** and misalign rail ends.

(iv) Keep cutting rail with rail saw until it stops moving; this may require several cuts.

(v) **After rail stops moving, unfasten rail for minimum required distance on both sides of the cut starting at the cut and working away from the cut.**

(vi) After unfastening CWR, continue cutting rail out until there is no more movement; at this point the rail ends should just be touching.

(vii) Measure and record the rail temperature.

(viii) Refer to MassDOT's preferred RLT (105°F) and compare it with the measured rail temperature to determine the distress *temperature differential*. If the measured rail temperature is *lower* than the RLT, proceed to Form "RC," "Report of Rail Clipping/Anchoring" in Attachment E to determine the additional rail to be removed.

(ix) If the measured rail temperature is *above* RLT, no additional rail needs to be removed, and proceed to next step.

(8) Rail shall be expanded by ambient temperature and/or pulled with a rail puller.

(9) f CWR is cut with a torch, both rails on either side of the torch cut shall have to be cut back at least 2" with a rail saw (see Paragraph (g) above).

(10) A plug rail **shall** have to be added. A minimum 18' plug in tangent track shall be installed.

(11) Rail to be cut out when an 18' plug rail is installed includes:

(i) The length of the plug rail.

(ii) The amount that the rails on either side of the torch cut are to be expanded from Form "RC," "Report of Rail Clipping/Anchoring." See Attachment E.

(iii) An additional 1" allowance for each end of the plug if it is to be field welded (2x1" = 2").

(iv) If installed plug rail is to be jointed and not welded, no additional rail for welding needs to be removed. Comply with FRA §213.119(c).

(v) DO NOT ADD RAIL.

(12) If field welding, add the weld allowance (usually 1") to the CWR rail expansion value and cut out the indicated amount of rail.

(13) Make the weld or install joint bars and reapply rail fasteners or anchors. (Note: some pulling of the rail may be required to close rail to welding gap.)

(14) Record distress temperature differential, distress length, unfastening length, the readjusted RNT, and the amount of rail removed on Form "TD."

(15) Proceed to distress the other rail.

(j) Distressing Curves Procedures:

(1) Curve distressing may be required in curves when curves have chorded in or moved in during cold temperatures or due to heavy maintenance activities in curves such as:

(i) Out-of-face surfacing and aligning of track

(ii) Out-of-face tie installation

(iii) Undercutting of track

(iv) Shoulder ballast cleaning

(2) Heavy maintenance activities performed when CWR is in tension generally makes curve move in and/or chord in.

(3) More specifically, when curves undergo lateral movements due to temperature changes, either naturally or due to maintenance, the result can be substantial changes in neutral temperature which requires readjustment by distressing.

(4) There are two methods of distressing curves: (1) cutting rail out (preferred), and (2) curve realignment out.

(5) Distressing via curve realignment is the easier of the two methods, but requires knowledge of the curve position (i.e., the amount of movement), hence, requires curve staking, monitoring, record keeping, and correct tamper lining management.

(6) Appendix “A” addresses the need to stake curves ≥3°. **At a minimum, curves ≥3° shall be staked when surfacing and aligning when the rail temperature is below 55°F or 50°F below the preferred RLT of 105°F.** See Form “TM,” “Report of Track Movement” in Attachment E.

(7) Staking of curves: At a minimum, stake curves ≥3° prior to out-of-face surfacing and lining.

(8) MassDOT Rail and Transit Division may require the staking of curves for other types of work as given in (j) (1).

(9) Place a minimum of three reference stakes uniformly spaced around the curve. Additional stakes may be required due to the overall length of the curve (see Form “TM,” Attachment E).

(10) Inspecting for curve movement: Inspect for curve movement periodically after the work, especially during periods of large temperature changes. **Where a curve has been staked and curve has chorded 3" or more (≥3") to the inside, the curve shall be lined out and/or distressed.**

(11) **A temporary speed restriction (TSR) of 40F/40P MPH or less shall be applied if the curve is not lined out or the rail is not distressed when the rail temperature reaches the target RLT of 105°F.** Take additional remedial action as required.

Example 1: Programmed Distressing (spot distressing): It is suspected that a 1,000' section of rail on wood ties with cut spikes and DSC plates and anchors was laid “cold” (well below the territory’s RLT), and it needs to be distressed to readjust to RLT = 105°F. The rail is being cut for distressing at a rail temperature of 70°F. How to proceed?

Step 1: Add match marks on both sides and within 10' of the rail to be cut. From these match marks determine the amount of rail moving together when the rail is cut. Place marks at 50' stations for up to 200' on either side of the proposed rail cut to monitor and record rail movement when rail is cut and then when rail is expanded to a RNT of 105°F.

Step 2: Add “witness stakes” in area where rail is to be cut. Measure any panel “pull back” on both sides of rail cut. Panel “pull back,” if any in inches, must be added to required rail expansion discussed below. **DO NOT ADD RAIL**

Step 3: For this example assume that the rail is in compression. Cut rail at midpoint with a rail saw if possible and bypass rail ends. If the rail is in compression, torch cutting may be required. If torch cutting is required an 18' plug or larger shall have to be cut in because the minimum cut back with a rail saw on either side of a torch cut is 2" or a minimum of 4" of rail plus the width of the torch cut is removed.

Step 4: For this example assume the rail was able to be cut with a saw. This means that the rail had a neutral temperature just below 70°F.

Step 5: From match marks determine amount of rail moving together.

Step 6: Unfasten 500' in both directions starting from the rail cut and working away from the rail cut. After anchors are removed, tap or vibrate rail and let rail continue to run. Place base of rail on spikes and/or rollers to get rail out of plates if that helps to expand rail. Add spikes and/or rollers starting at joint or cut and working backwards to beginning of string to be expanded.

Step 7: Record total rail movement on Form “TD” at a rail temperature of 70°F.

Step 8: Cut out the excess rail moved together, leaving the rail ends just touching. At this point this unfastened rail has a neutral temperature of 70°F which needs to be raised to RLT=105°F.

Step 9: Check rail temperature and refer to "Report of Rail Clipping/Anchoring," Form "RC" in Attachment E to compute required expansion in inches for a temperature differential of 105°F - 70°F = 35°F and calculate the gap required for two pieces at 500' or; 2 x 1-3/8" = 2-6/8" or 2-3/4".

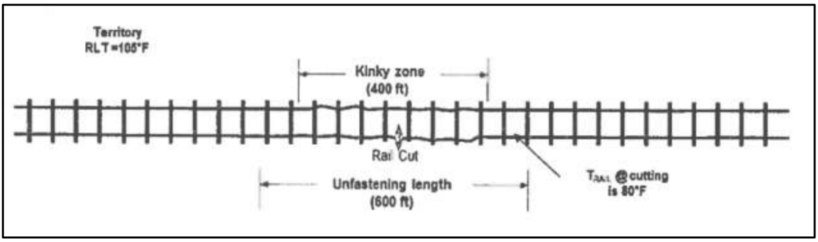
Step 10: Expand rail with ambient temperature and/or rail puller.

Step 11: Cut out the 2-3/4" + 1" for field weld allowance; pull the rail together for the 1" gap, field weld and reapply anchors.

Step 12: Record total amount of rail removed, distressing temperature, temperature differential, and the readjusted neutral temperature on Form "TD."

Step 13: Proceed to distress the other rail.

Example 2: Reactive Distressing: Adjusting Tight, Wavy, Nervous Rail: There is a 400' rail segment exhibiting a wavy/tight rail condition or rail kink. A kink is a formation or a misalignment greater than 1" on track not related to work done by MW Forces. A kink normally occurs when rail temperatures are thought to be high. The territory's RLT is 105°F, and the distressing is done at a rail temperature of 80°F. How to proceed with the distressing?



Step 1: Distress length is 400'; cut rail out with torch at midpoint until no more rail movement.

Step 2: Remove fasteners for 1.5 x kinky zone or 600' (300' on either side of cut note 600' = 1.5 x 400). Start at the torch cut and remove fasteners moving away from the cut. Keep letting rail run until no more rail movement.

Step 3: Measure rail temperature (here 80°F); and compare with RLT = 105°. The temperature differential is 25°F.

Step 4: Here the rail temperature is **lower** than laying temperature; therefore more rail needs to be removed. So rail needs to be expanded. See Form "RC," Attachment E.

Step 5: Proceed to Attachment E to determine additional rail to cut out for a 25°F distress temperature differential and the (2x300') 600' length, this is 1-1/4".

Step 6: Cut out the rail expansion required of 1-1/4" plus the 1" weld allowance if rail is to be field welded.

Step 7: If CWR is torch cut, both rails on either side of the torch cut shall have to be cut back at least 2" with a rail saw. Because only 1-¼" of expansion is required, a plug rail will have to be cut in. A minimum of 18' plug shall be installed in tangent track. Rail to be cut out if an 18' plug rail is installed includes:

- The length of the plug rail.
- The amount that the rails on either side of the torch cut are to be expanded from Form "RC." In this case 2 x 5/8" = 1-1/4" total.

- An additional 1" allowance for each end of the plug if it is to be field welded (2X1" = 2").
- If the plug is to be jointed and not welded, no additional rail other than the plug length and the required expansion amount of 1-¼" needs to be removed. Comply with FRA §213.119(c).
- **DO NOT ADD RAIL.**

Step 8: Expand rails (both sides of torch cut) by the ambient temperature and with a rail heater and/or rail puller, cut in plug rail, reapply anchors or fasteners, make field welds and/or drill rail ends and apply 6 hole joint bars.

Step 9: Record rail temperature (80°F); RLT (105°F); distress length (400'); unfastening length (600') and 1-1/4" rail cut out on Form "RC."

Step 10: Proceed to distress other rail.

ATTACHMENT C

RECOMMENDED PROCEDURES (RPS) FOR READJUSTING/DISTRESSING CONTINUOUS WELDED RAIL (CWR) AFTER A BREAK, PULL-APART (SERVICE FAILURE) OR CUT BELOW THE TARGET RAIL LAYING TEMPERATURE (RLT = 105°F)

(a) **Definitions:**

(1) The “Rail Laying Temperature” (RLT) is the target installation temperature of welded rail for the MassDOT Rail and Transit Division.

(2) For existing CWR in track, when service failures are repaired and cuts in CWR are made by Railroad Operating Companies, the minimum acceptable RLT to be achieved when making repairs and/or cuts is RLT -10°F or 95°F.

(3) All readjustments/distressing of CWR on MassDOT Rail and Transit Division shall be made to achieve a target RLT of at least 105°F.

(4) As per Section 3.0, “Installation and Adjustment of CWR,” MassDOT requires rail to be installed at RLT=105°F with construction tolerance of -10 to +10°F (i.e., 95°F to 115°F).

(5) The “Rail Neutral Temperature” (RNT) is the rail temperature at which the net longitudinal force in the rail is zero, and is referred to as rail neutral temperature.

(b) **Overview:**

(1) These procedures address readjusting the RNT under the following conditions:

(i) Service Failures:

- Broken joint bars
- Broken welds/field or plant
- Pull-aparts with broken bolts and bent bolts
- Broken rails
- Defective glued plug insulated joint rails

(ii) Rail defect or rail removals (cutting rail).

(iii) Cutting rails and installing plug rails.

(2) Rail that has pulled apart, broken, or been cut for defect removal must be readjusted to the RLT -10 safe range prior to rail temperatures exceeding those outlined in Table 1 below.

Table 1. Temperature When CWR (RNT) Must be Adjusted or Speed Restrictions Applied For Rail Breaks on One Rail Only

Rail Temperature (°F) at Which Rail Break or Cut Occurred	Rail Temperature (°F) at Which to Readjust or Apply Temporary Speed Restriction (TSR)
60	110*
50	110*
40	110*
30	110*
20	110*
10	110*
0	105*
-10	100*
-20	95*
-30	90*
*Table based on FRA/RSAC, but modified for MassDOT Rail and Transit Division requirements.	

Note: For the special case where both rails break and/or are cut within 200' of each other and when both rail's readjustment and permanent repairs are deferred to warm temperatures, the following formula shall apply:

T Return = (T RB1 + T RB2)/ 2 +70°F, and T Return shall not exceed 110°F.

(As an example, rail 1 breaks at 10°F, and rail 2 at 30° F, the return temperature is 90°F, and NOT as would be individually designated by Table 1)

(3) If rail RNT has not been adjusted prior to rail return temperatures exceeding the values in Table 1:

(i) **A temporary speed restriction (TSR) of not more than 25F/25P MPH shall be applied**, or

(ii) A temporary speed restriction of not more than 40F/40P MPH can be applied when a mandatory daily inspection is conducted during the heat of the day.

(iii) **If rail return temperatures do not exceed Table 1 values, the RNT shall be readjusted within 365 days.**

(4) The following data must be recorded on Form "TD" at the time of the break, pull-apart, and/or cut:

(i) Rail temperature at the time of the pull-apart/break/cut,

(ii) Gap size (as measured within ± 1/32"),

(iii) Rail size,

(iv) Tie type (wood or concrete),

(v) Anchor/fastener type (anchors or elastic fasteners); and the condition as described by "weak", "average", and "strong" as described below:

- Weak: missing anchors; the majority are not tight against the ties; evidence of rail slipping or moving longitudinally through anchors/clips;

crib ballast more than 2" below the tops of the ties; poor tie condition; more than half of the tie insulators are cracked, broken or not seated in the shoulder; tie pads are slipping or deteriorated; evidence of rail seat abrasion.

- Average: anchors are in place and tight against the ties; no evidence of rail creep; tie condition is good; full ballast section; most insulators are sound and seated correctly; tie pads are not worn or moving in the rail seat; no evidence of rail seat abrasion.
- Strong: new construction or relay rail with new anchors or fasteners; full ballast section and well consolidated AND which do not exhibit any of the “weak” or “average” characteristics.

(vi) The anchor pattern (every tie versus every other tie), and

(vii) If any “special conditions” apply* (see (5) below).

(5) Attachment A tables for the determination of pre-break/cut RNTs, do not apply for “special conditions” which are defined as:

(i) Breaks/cuts clustered in “close” proximity to each other on the same rail (i.e., within 800' of each other);

(ii) Breaks/cuts are within 400' of a “fixed” point; or

(iii) Breaks/cuts in iced rail/frozen ballast conditions.

(6) Use the tables in Attachment A to determine the pre-break/cut RNT, but note special conditions and/or exclusions (as above). Table 2 provides a guide as to the information found and where it is located in Attachment A (see below):

Table 2. Attachment A Table Use

Rail Base Size	Rail Weight	Anchorage Type	Attachment A Table to Use
6"	136/132	Every other tie anchored	1A
5-1/2"	115/100	Every other tie anchored	1B
6"	136/132	Every tie anchored*	2A*
5-1/2"	115/100	Every tie anchored*	2B*
* Use for concrete ties, and for wood ties with elastic fasteners.			

(7) 6" base rail found in Attachment A is currently the standard rail being purchased and installed by the MassDOT Rail and Transit Division.

(8) 5-½” base rail found in Attachment A was laid on MassDOT Rail and Transit owned rail lines and is still in track.

(c) **Procedures Used to Readjust Rail When A Service Failure Occurs and/or CWR Is Cut**

(1) The procedures used to readjust rail after a break or cut vary based upon Table 3’s summary below.

Table 3 – RNT Readjustment Procedures Summary

APPLICATION	DESCRIPTION
Attachment A + Tables 1 & 2	Evaluation of pre-break/cut RNTs and return temperatures for adjustment. Results are required inputs Scenarios 1-3.
Scenario 1a	RNT readjustment procedure when repairing broken/defect cut rail when it can be performed at the time of break/cut. Such requires a pre-break/cut RNT in the RLT-10 range thus allowing rails to be pulled together through anchors and fasteners for an RNT restoration to RLT-10
Scenario 1b	Same as 1a, but when additional rail removal is required for readjustment, and when rail is pullable through anchors/fasteners. This Scenario provides additional rail removal required for RNT restoration to RLT-10
Scenario 2	Procedure for readjusting RNT after rail break/defect cut when interim repairs are required (such rail addition via plug) and when RNT readjustment are deferred for a later time as per Table 1 at which time conventional destressing of 780 ft of rail is required to RLT
Scenario 3	Readjustment procedure for special cases when Attachment A is NOT applicable. These include: (a) Multiple breaks on same rail within close proximity (800 ft) of each other (b) Breaks/cuts within 400 ft of fixed points (bridges, tunnels, crossings, switches/turnouts, etc.) (c) Extremely stiff, frozen rail/ballast conditions

Notes: *(i) if for any reason in 1a or 1b the rail gap to be closed for adjustment is NOT pullable through anchors/fasteners, revert to Scenario 2, (ii) Scenario 3's (a) and (b) reverts to Scenario 2, and (iii) Scenario3's (c) is as indicated in Table 5*

(2) **Scenario 1a: Breaks or cuts occurring when the pre-break/neutral temperature was within the RLT -10°F range when a permanent repair is possible**. Repairs can be made at the time of the break/cut by pulling rail ends together with a rail puller without any removal of anchors or clips. Attachment A is used to determine existing and final (repaired) RNT.

(3) **Scenario 1b: Breaks or cuts occurring when the pre-break/cut neutral temperature was below the RLT -10°F range when a permanent repair is possible by cutting additional rail out**. Repairs can be made at the time of the break/cut by pulling rail ends together with a rail puller without any removal of anchors or clips. Attachment A is used to determine extra rail to cut out, and existing and final (repaired) RNT. If repairs cannot be made by pulling, then see Scenario 2 under (4).

(4) **Scenario 2: Breaks or cuts occurring, when permanent repairs cannot be made at the time of the break/cut.** If a plug is added (RAIL IS ADDED), or the rail pulled together and bolted as an interim repair, then permanent repairs or adjustments to the RNT shall be made before reaching the rail return temperature in Table 1, and by distressing 780' of rail.

Note that under this Scenario:

(i) the readjustment here is to RLT (and NOT to RLT-10), and

(ii) the potential benefit of the single joint interim repair approach versus the plug rail (i.e., offering the 1 weld vs. 2 welds later upon readjustment), and

(iii) the interim benefit of rail pulled together approach's resetting reduced RNT to the pre-break value.

(5) **Scenario 3: For "Special Cases"** where breaks or cuts occur:

(i) in close proximity on the same rail, or;

(ii) near fixed structures, or;

(iii) in extremely stiff or frozen rail/ballast conditions.

NOTES:

(a) **IN THE ABOVE CASES, TABLES IN ATTACHMENT "A" DO NOT APPLY (I.E. PRE-BREAK/CUT RNTs CANNOT BE DETERMINED.)**

(b) **SCENARIO 3 ADJUSTMENT OF RLT IS AS GIVEN IN SCENARIO 2 (I.E. REQUIRING RETURN TEMPERATURES AS PER TABLE 1, AND UNFASTENING/DISTRESSING 390' OF RAIL ON EITHER SIDE OF THE BREAK/CUT, OR 780' TOTAL, WITH THE EXCEPTION OF (iii) WHICH ADOPTS TABLE 5 FOR DISTRESS LENGTHS). SEE BELOW.**

(d) **Recommended Procedures to Readjust Rail RNT.** The procedures used to readjust rail after a break and/or service failure or cut are given below for the above Scenarios:

(1) **Scenario 1a: Single Break/Cut Occurred when the RNT was Within 10° of the RLT (105°-10=95°F), when a permanent repair is possible at the time of break/cut. Note the following:**

(i) Rail can be pulled together through the anchors or fasteners and the gap can be closed. A minimal amount of anchors are removed around the service failure and/or at the cut in CWR.

(ii) Permanent repair is made when service failure is discovered or CWR is cut.

(iii) RNT is restored to within the range of RLT -10°F.

(iv) No rail is added.

(v) No additional repairs are required (except for repositioning displaced anchors/fasteners resulting from rail pulling).

(vi) Following are the steps to be followed when making a repair:

- Step 1: Obtain the rail temperature at the time of the break/cut, gap size, rail size, tie type (wood or concrete), anchor/fastener type, and the anchor pattern (every tie versus every other tie) and record on Form "TD."
- Step 2: Use Table 2 above to determine which table in Attachment A should be used to determine the pre-break/cut RNT.
- Step 3: determine if the pre-break/cut temperature is within 10°F of the RLT. If so, proceed to Step 5.
- Step 4: If not, proceed to Scenario 1b or 2 depending upon the conditions.
- Step 5: No adjustment is required for breaks or cuts that occurred when the pre-break/cut RNT was within the RLT -10°F. The gap can be closed using the following procedures:
  - Remove a limited number of anchors or fasteners (<u>~5-10 ties</u>) either side of the break/cut (to facilitate an easier rail pull).
  - Cut 1" for the weld allowance if the rail ends are to be welded.

– Use a rail puller to close the gap or to leave the 1" weld allowance. If the gap closes, apply joint bars or make the weld and record all pertinent data.

– If the gap does not close, close the gap by adding a plug rail. Record the gap size, temperature, and the rail added, and return later to readjust using Scenario (2).

– After applying joint bars or making the weld, record the gap size, pre-break/cut RNT, the restored RNT and rail temperature on Form "TD." Permanent repairs at the service failure, break and/or cut location shall be made within 30 days in accordance with FRA §213.119(c)(3).

– If working in a curve, proceed to check alignment to be sure rail has not chorded in after pulling rail with a rail puller. Realign if necessary.

(vii) Above procedure requires pulling rail through the anchors or fasteners; hence, needing sufficient puller/tensor capacity especially in concrete tie track or on wood ties with elastic fasteners. If puller capacity is not adequate or puller is not available, use procedures in Scenario 2

(viii) MassDOT Rail and Transit Division requires that all permanent repairs that can be made immediately (Scenario 1), be accomplished by adjusting RNT to at least RLT -10°F or 95°F**.**

(ix) ILLUSTRATIVE EXAMPLE OF SCENARIO 1a:

Consider a rail break or defect removal on wood tie, every other tie anchored (EOTA) 136# rail segment, when the rail broke/cut at 40°F, and the resulting gap size is 3 inches. How to make the repair/readjustment?

<u>**ANSWER**</u>: from Table 1a (ATTACHMENT "A") the pre-break cut RNT is: <u>99°F</u>. This is within MassDOT's RLT-10 safe range (i.e. within 105 – 10), hence a candidate for Scenario 1a! After cutting an extra inch for the weld allowance, close the gap to the 1" weld gap via rail puller (without any anchor removal), and proceed to make the weld. Record all pertinent data, and be sure to reposition any moved/displaced anchors. Then the readjusted RNT here is 99°F.

<u>**Note**</u>: if for any reason the rail could not be pulled together, proceed to make an interim repair via a plug rail requiring adding 3" of rail, and then apply Scenario 2 to readjust before rail temperature exceed 110°F (as per Table 1)

(2) **Scenario 1b: Single Break/Cut RNT is below the RLT -10°F Range (<95°F), when a permanent repair is still possible. Note the following:**

(i) This is a modification of Scenario 1a as it requires more rail to be cut out to compensate for the RNT being below RLT -10°F. As such, this requires pulling rail together through "*larger*" gaps. The gap now consists of the sum of present break/cut gap, and the additional rail removal required to compensate for pre-break/cut RLT being below RLT -10°F as well as the 1" weld allowance if field welding. The **Required Steps When RNT is below RLT -10°F Range (<95°F):**

- Step 1: Measure/record the rail temperature at the time of the break/cut, gap size, rail size, tie type (wood or concrete), anchor/fastener type, and the anchor pattern (every tie versus every other tie) and record on Form "TD."

- Step 2: Use Table 2 information to choose appropriate table in Attachment A to determine the pre-break/cut RNT.
- Step 3: Determine if the pre-break/cut temperature is below the RLT -10°F. If so proceed to Step 4. If above the RLT -10°F range, proceed to Scenario 1a depending on the conditions and schedule readjustments in compliance with the rail return temperature in Table 1. **Step 4: Use the selected table in Attachment A to determine the *additional* amount of rail to cut out to readjust to at least 95°F.** Add this amount rail to be removed to the existing gap size plus the 1" weld allowance, if a weld is to be made~~.~~ This is known as the final pull-gap amount (i.e., FG.).
- Step 5: Determine if FG is *pullable,* with the rail puller on site, to the 1" gap required for welding or closing the gap if joint bars are to be added~~,~~ remembering that rail is to be pulled through the anchors/fasteners without removal. If gap is pullable, proceed to Step 6.
- Step 6: Cut out additional rail required for expansion and closing the joint by adding joint bars or by field welding. Pull rail through the anchors to close the gap for joint bars and/or leave 1" to close with a field weld.
- Step 7: If required gap cannot be closed, there are two possible temporary repairs. They are:
  - Only close the gap that was found in the field when the rail broke and/or was cut. The RNT will be the existing RNT when the rail broke and/or was cut as determined from Attachment A. Return to make permanent repair in accordance with Scenario 2 and Step 8.
  - If initial gap observed when rail broke and/or was cut cannot be closed, add rail by installing a plug rail. The RNT will be the existing rail temperature when the rail broke and/or was cut. Return to make permanent repair in accordance with Scenario 2.
- Step 8 After making permanent repairs as in Step 6, inspect fasteners and readjust (reposition anchors) where necessary so they are tight against the tie.
- Step 9: If working in a curve, proceed to check the alignment to determine if the rail has chorded in. Realign if necessary and or take appropriate remedial action.

(3) ILLUSTRATIVE EXAMPLE OF SCENARIO 1b:

Consider a 136# rail is cut for a defect removal at a rail temperature of 20°F in an every tie fastened rail segment resulting in a rail gap of 2". The territory's designated laying temperature is 105°F. How to make readjustment in line with the RLT-10 criterion at the time of defect cut?

<u>Answer</u>: apply Scenario 1b (as illustrated below)

Table 2a. 6-in base rail Every tie anchored

	Rail Gap																	
Rail Break Temp	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**
60	90	102	111	[illegible]	126	133	[illegible]	144	149	154	159							
55	85	97	106	[illegible]	121	128	[illegible]	139	144	149	154	158						
50	80	92	101	[illegible]	116	123	[illegible]	134	139	144	149	153	157					
45	75	87	96	[illegible]	111	118	[illegible]	129	134	139	144	148	152	156				
40	70	82	91	[illegible]	106	113	[illegible]	124	129	134	139	143	147	151	155			
35	65	77	86	[illegible]	101	108	[illegible]	119	124	129	134	138	142	146	150	154		
30	60	72	81	[illegible]	96	103	[illegible]	114	119	124	129	133	137	141	145	149	153	
[illegible]	55	67	[illegible]	[illegible]	91	98	[illegible]	[illegible]	114	119	124	128	132	136	140	144	148	151
20	[illegible]	[illegible]	[illegible]	79	86	[illegible]	99	[illegible]	109	114	119	123	127	131	135	139	143	146
[illegible]	45	57	[illegible]	[illegible]	81	[illegible]	[illegible]	99	104	109	114	118	122	126	130	134	138	141
10	40	52	61	69	76	83	[illegible]	94	99	104	109	113	117	121	125	129	133	136
5	35	47	56	64	71	78	[illegible]	89	94	99	104	108	112	116	120	124	128	131
0	30	42	51	59	66	73	[illegible]	84	89	94	99	103	107	111	115	119	123	126
-5	25	37	46	54	61	68	74	79	84	89	94	98	102	106	110	114	118	121
-10	20	32	41	49	56	63	69	74	79	84	89	93	97	101	105	109	113	116
-15	15	27	36	44	51	58	64	[illegible]	74	79	84	88	92	96	100	104	108	111
-20	10	22	31	39	46	53	59	[illegible]	69	74	79	83	87	91	95	99	103	106
-25	5	17	26	34	41	48	54	[illegible]	64	69	74	78	82	86	90	94	98	101
-30	0	12	21	29	36	43	49	[illegible]	59	64	69	73	77	81	85	89	93	96
-35	-5	7	16	24	31	38	44	[illegible]	54	59	64	68	72	76	80	84	88	91
-40	-10	2	11	19	26	33	39	44	49	54	59	63	67	71	75	79	83	86
-45	-15	-3	6	14	21	28	34	39	44	49	54	58	62	66	70	74	78	81

Pre break RNT is 79°F hence <u>NOT</u> in the RLT-10 safe range of 95 to 105°F. <u>BUT</u> 99°F at a 3.5" gap is! Hence cut an extra 1.5" leaving a new gap of 3.5". Cut an additional 1" for the weld allowance; pull rail to close gap to 1" without fastener removal and weld. This rail has been readjusted to 99°F and to within the RLT-10 range as required!

(e) **Procedures to Readjust Rail RNT for Scenario 2**

(1) Scenario 2: Breaks or cuts occurring when permanent repairs cannot be made at the time of the break/cut. If a plug is added as an interim fix, then permanent repairs or adjustments to the RNT shall be made before reaching the rail return temperature in Table 1.

(i) Step 1: Use Attachment A Tables to document pre-break RNTs.

(ii) Step (2): **If a plug rail is cut in, record the amount of rail added on Form "TD."**

(iii) Step (3): A special requirement of Scenario 2 is to distress by removing anchors or clips on 390' of CWR on both sides of plug or joint (for a total of 780') when returning for repair, and readjusting to RLT of 105 **°F** (and not to RLT-10)

(2) ILLUSTRATIVE EXAMPLE OF SCENARIO 2:

***Example**: a 136# rail is cut for a defect removal at a rail temperature of 20°F in a concrete tie territory resulting in a rail gap of 2". The territory's designated laying temperature is 105°F. Scenario 1b was attempted but the rail could not be pulled together to close the 3.5"gap (see example above). How to proceed?*

***ANSWER:** follow Scenario 2 (with Options 1 or 2 below):*

OPTION 1 - in case rail could not be pulled together to close the 3.5" gap, the procedure is to apply Scenario 2. This requires recording/documenting all pertinent data, and making interim plug repair of adding 2" of rail and applying Table 1 to establish return temperature for adjustment (i.e. in this case prior to rail temperatures exceeding 110°F). Return at or prior to this rail temperature and make adjustment as per Scenario 2 which requires adjustment by destressing via unfastening ± 390 ft of rail (total of 780 ft).

OPTION 2 - instead of making interim plug repair of adding 2" of rail as per above, consider pulling rail together through the 2" gap (without unfastening) and closing rail via bolted joint. This restores RNT to 79°F. It is still required to return for a later adjustment, but Table 1 doesn't apply anymore in this case, hence more flexibility on when to return for the final adjustment. The required unfastening length is still ±390ft (780ft total).

Note: Option 2 has the benefit of some immediate *partial RNT restoration* (thereby offering some interim safety against a buckling potential during the onset of warm temperatures), and an easier final adjustment of requiring one weld versus two.

(f) **Procedures to Readjust Rail RNT for Scenario 3 (Special Cases) when:**

(1) Case 1: Multiple breaks/cuts occurring in "close" proximity on the same rail (i.e., within 800' of each other).

(2) Case 2: Breaks/cuts within 400' of "fixed structures/locations."

(3) Case 3: Breaks/cuts in iced rail/frozen ballast conditions.

(4) Case 4: Where the break/cut occurs on both rails within 200' of each other.

(5) For detailed readjustment procedure for Special Cases 1 and 2 above refer to conventional distressing procedure and application of Scenario 2 as in (e) above, requiring the adjustment of 780' of rail and cutting rail out as dictated by the temperature differential (TD).

(6) Use Table 4 below with the caveat that additional rail removal may be required if the end points at ±390 are measured to be moving in when applying the rail puller to close the gap.

Table 4. Special Cases: Additional Rail to Remove for Readjustment for the 780' of Unfastening Length

Temperature Differential (°F)*	Additional Rail to Remove (inches)
5	1/4
10	1/2
15	1
20	1-1/4
25	1-1/2
30	1-3/4
35	2-1/4
40	2-1/2
45	2-3/4
50	3-1/4
55	3-1/2
60	3-3/4
65	4
70	4-1/2
*MassDOT Rail and Transit Division Preferred Rail Laying Temperature (RLT=105°F)	

<u>Note:</u> The above procedures for Scenario 2 and Scenario 3"s Special Cases 1 and 2 are based on best practice engineering assumption, that for **<u>all</u>** rail break/defect cut/pull-apart cases, **<u>one</u>** unfastening length of 390' on either side of the cut/break is adequate for readjustments. Although some break/cut influence zones can be longer, hence requiring longer unfastening lengths, the 780' total length is an acceptable "best practice" compromise. For "*bad*" breaks (i.e., break gaps exceeding 3"), longer unfastening lengths are recommended. Additionally, note that the above Scenario 2 procedure readjusts to RLT instead of the RLT -10°F value! This is for "added safety" to counteract the "*one unfastening length of* $\pm$ *390' satisfying all break/cut influence zone"* assumption.

(g) **Procedures to Readjust Rail RNT Scenario 3:** For Special Case 3 (breaks/cuts in frozen rail/ballast conditions):

(1) Apply Scenario 2 as per (e) above; however, the recommended unfastening lengths are reduced as per Table 5 below.

(2) Use Form "RC" in Attachment E to calculate the required expansion amounts that correspond to the unfastening lengths given in Table 5.

Table 5. Unfastening Lengths for Frozen Ballast Conditions

Measured Gap Size (in) when Broke/Cut	Unfastening Length (ft) in Each Direction
<1/2	100
½ - 1	150
>1	200

(h) **Procedures to Readjust Rail RNT Scenario 3:** For Special Case 4 where the break/cut occurs on both rails within 200' of each other.

(1) Use Scenarios 1-3 as applicable for rail breaks on each individual rail.

(2) The return/readjustment time (return rail temperature) given in Table 1 is not applicable for this Special Case 4 when both rails have breaks in close proximity (within 200' of each other).

(3) The following formula must be used to determine the "return rail temperature."

$$T_{RETURN} = (T_{RB_1} + T_{RB_2})/2 + 70°F$$

Where T_{RB1} is the rail break temperature of one rail, and T_{RB2} is the rail break temperature of the other (opposite) rail.

(4) Example: One rail breaks or is cut for defect removal at 10°F and left for a later adjustment in line with Scenarios 2 or 3. The other rail breaks or is cut later at 30°F which is also deferred for later return adjustment. If both repairs were not made at the time of the rail break and/or cut, but were deferred to at a later date, then the return temperature is at/below a rail temperature of 90°F. The calculation is shown below:

T_{RETURN} = (10°F +30°F)/2 + 70°F or 20°F+70°F = 90°F

Note that this is a lower return temperature than either individual breaks/cut temperature given by Table 1.

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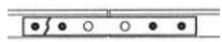
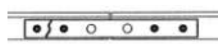
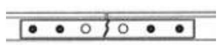
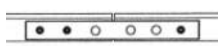
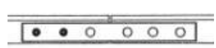
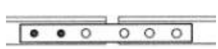
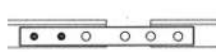
ATTACHMENT D

JOINT DEFECT GUIDELINES / MAXIMUM ALLOWABLE TEMPORARY SPEED RESTRICTIONS (TSR's)

Joint Defect Guidelines in CWR Track

Condition	FRA Part 213 Reference	Illustration****	Action
One Broken Joint Bar Not Between Middle Holes	§213.121(b) §213.121(e)		10F/15P MPH* (per FRA §213.9(b))
One Broken Joint Bar Between Middle Holes	§213.121(c)		Out of Service until Repaired (per FRA §213.9(b)) and Visually Supervise**
<u>Both</u> Joint Bars Broken Not Between Middle Holes	§213.121(b) §213.121(e)		10F/15P MPH* (per FRA §213.9(b))
<u>Both</u> Joint Bars Broken Between Middle Holes	§213.121(c)		Out of Service until Repaired (per FRA §213.9(b))and Visually Supervise**
Less than Two Bolts in Rail End	§213.121(e)		10F/15P MPH* (per FRA §213.9(b))
Unbolted Rail End Pulled Apart 1-1/2" - 2"	§213.121(e)		Inspect (per FRA §213.9(b)) Repair within 24 hrs.
Unbolted Rail End Pulled Apart 2" - 4"	§213.121(e)		Visually Supervise** Must maintain continuous communications w/train crew (per FRA §213.9(b)) Repair within 24 hrs.
Unbolted Rail End Pulled Apart >4"	§213.121(e)		Out of Service until Repaired

Notes:

* All speeds shown are maximum allowable. Qualified employees may impose more stringent remedial action (FRA §231.7(a)(b)(c)(d)), depending on the presence of a combination of defects or particular site conditions.

** "Visually supervise" means that an employee qualified under FRA §213.7(a)(b)(c) must observe each operation over the defect and/or in accordance with FRA §213.7(d).

*** Solid circle is bolt hole with bolt. Open circle is bolt hole without bolt.

****Track surface and joint tie conditions shall be considered when determining temporary slow order (TSO) maximum speeds.

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ATTACHMENT E

PREPARATION OF FORMS

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FORM "TD"
REPORT OF DISTURBANCE OF CWR TRACK

Part A: CWR Track Disturbance Due to Track Work					
Route:		**Date:**		**Rail Temp**	**Time:**
M.P. Location From:		**To:**		**Track No:**	
Type of Work Performed:					
Additional Repairs Required:					
Remedial Action Required:					
Part B: Rail Cut Or Service Failure in CWR Territory					
Route:		**Date:**		**Rail: North / South / East / West**	
M.P. Location From:		**To:**		**Track No:**	
Type of Work Performed:					
Additional Repairs Required:					
Remedial Action Required:					
Operating Railroad Employee (Print):					
Operating Railroad Employee (Signature):					

ATTACHMENT E

INSTRUCTIONS FOR PREPARATION OF THE REPORT OF DISTURBANCE OF CWR TRACK (FORM "TD")

A report of disturbed track , Form "TD", shall be made out as required by Section 10.0. The report will be completed and signed by the Contractor/Operating Railroad Employee in charge of the work as follows:

Part A - This part will be completed in its entirety any time heavy maintenance work is performed on CWR track. See Section 6.0, "Trackwork that Disturbs CWR Track and the Protection of Disturbed Track" for the information required on Form "TD", Part A.

Part B - This part will be completed any time main track CWR is cut or broken and/or there is a service failure.

A. See Section 5.0, "Maintenance of the Desired Rail Neutral Temperature in Previously Installed CWR" for the information required on Form "TD", Part B.

B. See Attachment C, "Recommended Procedures for Readjusting Continuous Welded Rail (CWR), After a Break, Pull-Apart (Service Failure) or Cut Below the Target Rail Laying Temperature (105°F)" for the information required on Form "TD", Part B.

C. See Attachment A, "Determination of Estimate of Pre-Break/Pre-Cut Neutral Temperature for a Service Failure in CWR" for the information required on Form "TD", Part B.

Parts A & B

A. Form "TD" shall be filled out in accordance with Section 10.0, "Reporting Requirements for CWR Track."

B. Form "TD" shall be filled out and kept by the Operating Railroad in accordance with Section 11.0, "Record Keeping."

FORM "TM"
REPORT OF TRACK MOVEMENT: CURVES >3°

Route:		**Type of Work Performed*:**	**Surfacing** ☐ **Install Ties** ☐			**Date of Work:**	
M.P. Location :	**From:**		**To:**			**Track No:**	
Curve No:			**Degree of Curve:**			**Elevation:**	
Rail Temperature at which Surfacing Tie Installation was Done:							

Distance from Reference
(Reference Points Must be no Further than 200 ft. apart):

Reference Point Number	Location of Reference Point	Before Work	After Work	Movement	Within 7 Days	Movement
TS (Tangent to Spiral Tag)						
SC (Spiral to Curve Full Body Tag)						
Additional Full Body Tag As Required**						
Additional Full Body Tag As Required**						
CS (Curve to Spiral Full Body Tag)						
ST (Spiral to Tangent Tag)						
Uniform Movement	----------	----------				

***Types of work that requires a Form "TD." Out-of-face surfacing and alinement and installing more than 540 ties per mile.**

Railroad Employee Making Measurements (Print Name): ______________________________

Railroad Employee Making Measurements (Signature): ______________________________

Railroad Employee in Charge of Surfacing (Print Name): ______________________________

Railroad Employee in Charge of Surfacing (Signature): ______________________________

**Use additional sheets if the number of stations exceeds the number of lines.

ATTACHMENT E

INSTRUCTIONS FOR PREPARATION OF THE REPORT OF TRACK MOVEMENT DUE TO SURFACING OR OUT-OF-FACE TIE RENEWAL (FORM "TM")

(a) In curves of 3° or over, prior to the start of high speed surfacing, or installing more than 540 ties per mile, the Operating Railroad and/or Contractor shall set reference points each curve at the locations given on Form "TM" along the gage side of the high rail of the curve.

In no case may the points be more than 200' apart.

(1) In no case will the points be more than 200' apart.

(2) In addition, offset stakes shall be set at each of the reference mark locations. These stakes will be set to the outside (high side) of the track, and out of the way of regulators or other equipment.

(3) In multiple track locations, a mark on the high rail or a tack in a tie on an adjacent and/or parallel track, may be used as an offset location.

(4) Adjacent and/or parallel tracks may be used for offset locations only if the track is not to be disturbed or will have any maintenance work performed when it is being used as for offset locations.

(5) Initial measurements shall be made from the reference points to the offset locations before any heavy maintenance work (The "Work") is performed and shall be recorded on Form "TM".

(b) Immediately after completion of the Work, the Operating Railroad Employee in charge of the track surfacing or tie installation will again measure and record the distances from the reference point to the offset locations. Both the distances and any movement shall be recorded on Form "TM".

(c) Within seven days after the Work, the Operating Railroad will again measure and record the distance from the reference point to the offset locations. Again, both distances and movement shall be recorded on Form "TM".

(d) If the curve has moved and/or chorded in at any location is 3" or more ($\geq$3"), the curve shall be distressed by lining out and/or distressing the rail prior.

(e) The lining out of the curve and/or distressing of the curve shall be accomplished before:

(1) If the ambient temperature is greater than 80°F (rail temperature greater than a temperature of 110°F), no work shall be done unless it is an emergency or as directed by MassDOT Rail and Transit Division and; or

(2) If the ambient temperature and/or rail temperature is less than 40°F, all work will be suspended unless it is an emergency or directed by the MassDOT Field Representative.

(f) **Temporary Speed Restriction:** A temporary speed restriction (TSR) shall be placed if the curve has moved inward 3" or more in accordance with Section 6(e), until the curve is lined out and/or distressed. The curve will be considered to have lost its neutral temperature if movement is recorded as given below:

Curves 3° and Over	Measured Curve Movement that Requires Lining Out the Curve and/or Distressing the Rail
	3" or greater ($\geq$3") to the inside

FORM "JE"
REPORT OF JOINT ELIMINATION BY FIELD WELDING
THERMITE (T) / FLASH BUTT (FB)

Track Name/No.	Rail (N/S/E/W)	MP	Rail Weight	Date/ Weld No.	Field Weld Type(2)	Mold Date	Portion Date	Weld Company/ Welder's Name	Weather/ Rail Temp °F	Rail Cut Out / or Consumed and/or Added (Inches)	Remarks	Weld Inspections			Results
												Date Inspected	Inspection Company	Test Results	

Notes:
(1) Reason for weld:
- EJ – Eliminate Joint
- EPR – Eliminate Plug Rail
- EDW – Eliminate Defective Weld
- RNT – Increase Rail Neutral Temperature

(2) Field Weld Types:
- T – Thermite
- FB – Flash butt

(3) A Form "TD" shall be made out when rail is cut and/or broken.

Operating Railroad Contractor's Signature: ______________________ **Date:** ______________

Operating Railroad Contractor's Name (Print): ______________________

ATTACHMENT E

INSTRUCTIONS FOR THE PREPARATION OF THE REPORT OF JOINT ELIMINATION BY FIELD WELDING (FORM "JE")

(a) A Report of Joint Elimination by Field Welding shall be made out as required in Section 10.0. The report shall be completed by the Contractor/Operating Railroad Employee in charge of the work.

FORM "RC"
REPORT OF RAIL CLIPPING/ANCHORING

Operating Railroad/Contractor:	**Weather:**
Line Segment:	**Copy sent to MassDOT Rail and Transit Division (Yes/No)"**

Date	Rail[6]	String Number	Start MP	End MP	String Length (Feet)	Rail Temp (°F)[(1)]	Required Temp. Change (°F)[(2)]	Required Expansion (Inches)[(3)]	Method of Expansion[(5)]	String Vibrated (Y/N)	Time Started/ Finished Clipping	Actual Expansion Recorded (Inches) Obtained at ¼ Points[(4)]				Notes
												1/4	1/2	3/4	Full	

Notes:
(1) Temperature to be measured with approved rail thermometer.
(2) Required temperature change in °F is preferred RNT of 105°F minus the actual rail temperature at the time of expansion.
(3) See formula and table on reverse side of Form.
(4) After string is anchored and/or clipped.
(5) Method of Expansion: Natural (N); Rail Heater (RH); Rail Puller (RP); Cooled (C).
(6) Rail locations" N, S, E, W

Operating Railroad Contractor's Signature: ______________________________ **Date:** ______________

Operating Railroad Contractor's Name (Print): ______________________________

ATTACHMENT E

INSTRUCTIONS FOR THE PREPARATION OF THE REPORT OF RAIL CLIPPING/ANCHORING (FORM “RC”)

Formula for Coefficient of Linear Expansion of Rail:

$A = 0.000078 \times (T_D - T_E) \times L$

A	=	Adjustment or Required Expansion amount for rail string (in inches)
T_D	=	Desired RNT which should be 105°F if possible as conditions permit
T_E	=	Existing or Actual Rail Temperature (°F) prior to heating or expansion measured with an approved rail thermometer
L	=	Length of string to be adjusted (in feet)

Calculations:

Change in Rail Length Due to Change in Rail Temperature

A = Change in Rail Length in Inches = 0.000078ΔT x L
L = Length of Rail to be Expanded in Feet
ΔT = Change in Temperature in Degrees Fahrenheit: Desired RNT minus Actual Rail Temperature

Length of Rail (ft)	Change in Temperature in Degrees Fahrenheit															
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	Change in Rail Length in Inches															
100	1/8	1/8	1/8	1/4	1/4	1/4	3/8	3/8	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8
200	1/8	1/4	1/4	3/8	1/2	1/2	5/8	5/8	3/4	7/8	7/8	1	1-1/8	1-1/8	1-1/4	1-1/4
300	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-3/4	1-7/8	1-7/8
400	1/4	3/8	1/2	5/8	7/8	1	1-1/8	1-1/4	1-1/2	1-5/8	1-3/4	1-7/8	2-1/8	2-1/4	2-3/8	2-1/2
500	1/4	1/2	5/8	7/8	1	1-1/4	1-3/8	1-5/8	1-7/8	2	2-1/4	2-3/8	2-5/8	2-3/4	3	3-1/8
600	1/4	1/2	3/4	1	1-1/4	1-1/2	1-3/4	1-7/8	2-1/8	2-3/8	2-5/8	2-7/8	3-1/8	3-3/8	3-5/8	3-3/4
700	3/8	5/8	7/8	1-1/8	1-3/8	1-3/4	2	2-1/4	2-1/2	2-3/4	3-1/8	3-3/8	3-5/8	3-7/8	4-1/8	4-3/8
800	3/8	5/8	1	1-1/4	1-5/8	1-7/8	2-1/4	2-1/2	2-7/8	3-1/8	3-1/2	3-3/4	4-1/8	4-3/8	4-3/4	5
900	3/8	3/4	1-1/8	1-1/2	1-7/8	2-1/8	2-1/2	2-7/8	3-1/4	3-5/8	3-7/8	4-1/4	4-5/8	5	5-3/8	5-5/8
1000	1/2	7/8	1-1/4	1-5/8	2	2-3/8	2-3/4	3-1/8	3-5/8	4	4-3/8	4-3/4	5-1/8	5-1/2	5-7/8	6-1/4
1100	1/2	7/8	1-3/8	1-3/4	2-1/4	2-5/8	3-1/8	3-1/2	3-7/8	4-3/8	4-3/4	5-1/4	5-5/8	6-1/8	6-1/2	6-7/8
1200	1/2	1	1-1/2	1-7/8	2-3/8	2-7/8	3-3/8	3-3/4	4-1/4	4-3/4	5-1/4	5-5/8	6-1/8	6-5/8	7-1/8	7-1/2
1300	5/8	1-1/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8	4-5/8	5-1/8	5-5/8	6-1/8	6-5/8	7-1/8	7-5/8	8-1/8
1400	5/8	1-1/8	1-3/4	2-1/4	2-3/4	3-3/8	3-7/8	4-3/8	5	5-1/2	6-1/8	6-5/8	7-1/8	7-3/4	8-1/4	8-3/4
1440	5/8	1-1/8	1-3/4	2-1/4	2-7/8	3-3/8	4	4-1/2	5-1/8	5-5/8	6-1/4	6-3/4	7-3/8	7-7/8	8-1/2	9
1600	5/8	1-1/4	1-7/8	2-1/2	3-1/8	3-3/4	4-3/8	5	5-5/8	6-1/4	6-7/8	7-1/2	8-1/8	8-3/4	9-3/8	10

FORM "CWR"

REPORT OF SEMI-ANNUAL INSPECTION (SPRING/FALL) OF CWR TRACK

Operating Railroad/Contractor:	**Weather:**
Line Segment:	**Copy sent to MassDOT Rail and Transit Division (Yes/No):**

Track No.	Rail (N/S/E/W)	MP (Start)	MP (Finish)	Ties		Ballast		Anchors			Longitudinal Rail Movement					Remarks/ Remedial Action Required
				Type	Condition	Crib	Shoulder	Type	Pattern	Position	Turnouts	Crossovers	Grade X-ings	Open Deck Bridges	Other	

Operating Railroad Contractor's Signature: ______________________ **Date:** ______________

Operating Railroad Contractor's Name (Print): ______________________

ATTACHMENT E

INSTRUCTIONS FOR THE PREPARATION OF THE REPORT OF SEMI-ANNUAL INSPECTION (SPRING/FALL) OF CWR TRACK

(FORM "CWR")

(a) A Report of Semi-Annual Inspection (Spring/Fall) of CWR Tack shall be filled out as required in Section 10.0. The report shall be completed by the Operating Railroad Employee making the inspection.

ATTACHMENT F

TORCH CUTTING RAIL (FIGURE/REMARKS)

(a) General: Cutting Continuous Welded Rail (CWR) In Compression:

(1) Cut rail with a torch any time the existing rail temperature is suspected of being above the Rail Neutral Temperature (RNT) and/or the rail is in tension.

(2) Rail in compression has many forms to include:

(i) Tight rail

(ii) Nervous/wavy rail

(iii) Kinky rail

(iv) Misaligned track

(v) Buckled track

(3) The area where the rail is in compression may exhibit the following characteristics:

(i) Rail is lifting out of the tie plates; or,

(ii) Rail is bunching and/or crowding shoulders of the tie plates; or,

(iii) Rail is moving longitudinally in anchors and/or elastic fasteners; or,

(iv) Ties are skewing; or,

(v) Crib and/or shoulder ballast is pushing due to longitudinal and/or lateral track movement; or,

(vi) There are numerous consecutive high spikes; or

(vii) The rail appears to be kinking; or

(viii) One rail appears to be straighter than the other opposite rail; or

(ix) There is noticeable variation in track gage.

(b) The Contractor and Operating Railroad shall have their own specific Safety Procedures developed for torch cutting rail.

(c) The Contractor and/or Operating Railroad shall designate personnel that are qualified and are trained on an annual basis to torch cut rail using the above Safety Procedures.

(d) Minimum Recommended Procedures When Torch Cutting CWR:

(1) Locate the area where the rail appears to be in compression; and

(2) If the track is already misaligned and/or buckled:

(i) Line track out at misalignment and/or buckle to reduce compressive stresses in the rail; and

(ii) Make cut away from misalignment and/or buckle area to make cut in an area of potentially reduced compressive forces.

(3) In all cases, make the torch cut, as shown below, before removing any spikes, lags or fasteners; and

(4) In all cases, make the torch cut, as shown below, before removing any joints and/or anchors or elastic fasteners; and,

(5) In all cases, make the torch cut in the rail as described and shown below.

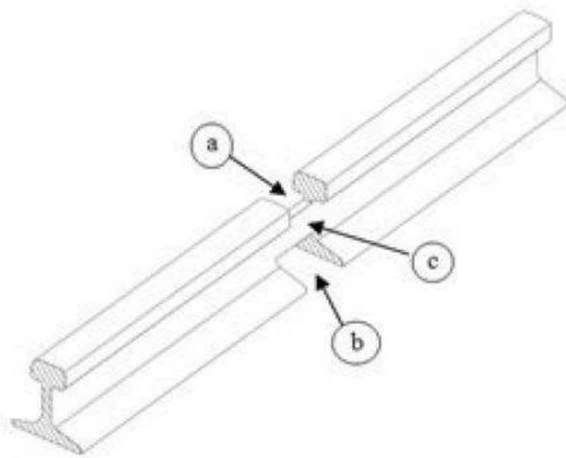
(e) Torch Cutting Rail In Compression: Use the so called “H” Pattern Method:

(1) First, cut and remove the rail head as shown in “a”; then

(2) Second, cut and remove both sides of the base as shown in "b"; then

(3) Third, cut and remove the remaining portion of the web from the top of the web near the rail head towards the base of the rail as shown in "c".

(4) Note: Removing the rail head and then both sides of the rail base, before removing the web of the rail, is preferred, in order, if possible, to minimize excessive vertical and/or lateral movement of the rail when the rail is cut.



(f) After Torch Cutting Rail:

(1) If the rail that is torch cut is to be field welded and/or jointed:

(i) Trim or cut back the torch cut rail ends with a rail saw.

(ii) Remove all indication of the torch cut and/or heat affected zone which can be accomplished by:

- Cutting back a minimum of 2" behind the torch cut on each rail end (AREMA Chapter 4); and/or
- Cutting back the heat affected zone from behind the torch cut on each rail end;
- Use whichever cut back amount is larger.

(iii) Also see Attachment B, Paragraph (g) "Torch Cutting CWR in Track."

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APPENDIX B

UNDERBALANCE TABLES
MAXIMUM ALLOWABLE OPERATING SPEED ON CURVES

APPENDIX B

UNDERBALANCE TABLES
MAXIMUM ALLOWABLE OPERATING
SPEED ON CURVES

Notes:

(a) The enclosed tables can be used to determine V_{max} in accordance with FRA §213.57.

(b) The Chief Engineer shall maintain a list of curves and the designated “underbalance” to be used.

(c) To operate at speeds which use “underbalance” greater than 3", the equipment must be qualified and approved by the Federal Railroad Administration.

(d) The Chief Engineer shall authorize all elevations in excess of 4".

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	Degree Curve (D)[2]	Superelevation in inches (E_a)			
		0-0	0-1/4	0-1/2	0-3/4
		Speed in Miles Per Hour (V_{max})			
0° 10'	0.17	90	90	90	90
0° 20'	0.33	90	90	90	90
0° 30'	0.50	90	90	90	90
0° 40'	0.67	80	83	86	89
0° 50'	0.83	71	74	77	80
1° 00'	1.00	65	68	70	73
1° 15'	1.25	58	60	63	65
1° 30'	1.50	53	55	57	59
1° 45'	1.75	49	51	53	55
2° 00'	2.00	46	48	50	51
2° 15'	2.25	43	45	47	48
2° 30'	2.50	41	43	44	46
2° 45'	2.75	39	41	42	44
3° 00'	3.00	37	39	40	42
3° 15'	3.25	36	37	39	40
3° 30'	3.50	34	36	37	39
3° 45'	3.75	33	35	36	37
4° 00'	4.00	32	34	35	36
4° 15'	4.25	31	33	34	35
4° 30'	4.50	30	32	33	34
4° 45'	4.75	30	31	32	33
5° 00'	5.00	29	30	31	32
5° 30'	5.50	27	29	30	31
6° 00'	6.00	26	27	28	29
6° 30'	6.50	25	26	27	28
7° 00'	7.00	24	25	26	27
7° 30'	7.50	23	24	25	26
8° 00'	8.00	23	24	25	25
8° 30'	8.50	22	23	24	25
9° 00'	9.00	21	22	23	24
9° 30'	9.50	21	22	22	23
10° 00'	10.00	20	21	22	23
10° 30'	10.50	20	21	21	22
11° 00'	11.00	19	20	21	22
11° 30'	11.50	19	20	20	21
12° 00'	12.00	18	19	20	21
12° 30'	12.50	18	19	20	20
13° 00'	13.00	18	18	19	20
13° 30'	13.50	17	18	19	19
14° 00'	14.00	17	18	18	19
14° 30'	14.50	17	17	18	19
15° 00'	15.00	16	17	18	18

(1) In degrees and minutes
(2) In decimals

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	Degree Curve (D)[2]	Superelevation in inches (E_a)			
		1	1-1/4	1-1/2	1-3/4
		Speed in Miles Per Hour (V_{max})			
0° 10'	0.17	90	90	90	90
0° 20'	0.33	90	90	90	90
0° 30'	0.50	90	90	90	90
0° 40'	0.67	90	90	90	90
0° 50'	0.83	82	85	87	90
1° 00'	1.00	75	77	80	82
1° 15'	1.25	67	69	71	73
1° 30'	1.50	61	63	65	67
1° 45'	1.75	57	58	60	62
2° 00'	2.00	53	55	56	58
2° 15'	2.25	50	51	53	54
2° 30'	2.50	47	49	50	52
2° 45'	2.75	45	46	48	49
3° 00'	3.00	43	44	46	47
3° 15'	3.25	41	43	44	45
3° 30'	3.50	40	41	42	44
3° 45'	3.75	39	40	41	42
4° 00'	4.00	37	38	40	41
4° 15'	4.25	36	37	38	39
4° 30'	4.50	35	36	37	38
4° 45'	4.75	34	35	36	37
5° 00'	5.00	33	34	35	36
5° 30'	5.50	32	33	34	35
6° 00'	6.00	30	31	32	33
6° 30'	6.50	29	30	31	32
7° 00'	7.00	28	29	30	31
7° 30'	7.50	27	28	29	30
8° 00'	8.00	26	27	28	29
8° 30'	8.50	25	26	27	28
9° 00'	9.00	25	25	26	27
9° 30'	9.50	24	25	26	26
10° 00'	10.00	23	24	25	26
10° 30'	10.50	23	24	24	25
11° 00'	11.00	22	23	24	24
11° 30'	11.50	22	22	23	24
12° 00'	12.00	21	22	23	23
12° 30'	12.50	21	22	22	23
13° 00'	13.00	20	21	22	22
13° 30'	13.50	20	21	21	22
14° 00'	14.00	20	20	21	22
14° 30'	14.50	19	20	21	21
15° 00'	15.00	19	20	20	21

(1) In degrees and minutes
(2) In decimals

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	Degree Curve (D)[2]	Superelevation in inches (E_a)			
		2	**2-1/4**	**2-1/2**	**2-3/4**
		Speed in Miles Per Hour (V_{max})			
0° 10'	0.17	90	90	90	90
0° 20'	0.33	90	90	90	90
0° 30'	0.50	90	90	90	90
0° 40'	0.67	90	90	90	90
0° 50'	0.83	90	90	90	90
1° 00'	1.00	84	86	88	90
1° 15'	1.25	75	77	79	81
1° 30'	1.50	69	70	72	74
1° 45'	1.75	63	65	67	68
2° 00'	2.00	59	61	62	64
2° 15'	2.25	56	57	59	60
2° 30'	2.50	53	54	56	57
2° 45'	2.75	50	52	53	54
3° 00'	3.00	48	50	51	52
3° 15'	3.25	46	48	49	50
3° 30'	3.50	45	46	47	48
3° 45'	3.75	43	44	45	46
4° 00'	4.00	42	43	44	45
4° 15'	4.25	40	42	42	43
4° 30'	4.50	39	40	41	42
4° 45'	4.75	38	39	40	41
5° 00'	5.00	37	38	39	40
5° 30'	5.50	36	36	37	38
6° 00'	6.00	34	35	36	37
6° 30'	6.50	33	33	34	35
7° 00'	7.00	31	32	33	34
7° 30'	7.50	30	31	32	33
8° 00'	8.00	29	30	31	32
8° 30'	8.50	28	29	30	31
9° 00'	9.00	28	28	29	30
9° 30'	9.50	27	28	28	29
10° 00'	10.00	26	27	28	28
10° 30'	10.50	26	26	27	27
11° 00'	11.00	25	26	26	27
11° 30'	11.50	24	25	26	26
12° 00'	12.00	24	25	25	26
12° 30'	12.50	23	24	25	25
13° 00'	13.00	23	24	24	25
13° 30'	13.50	23	23	24	24
14° 00'	14.00	22	23	23	24
14° 30'	14.50	22	22	23	23
15° 00'	15.00	21	22	22	23

(1) In degrees and minutes
(2) In decimals

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	Degree Curve (D)[2]	Superelevation in inches (E_a) 3	3-1/4	3-1/2	3-3/4
		Speed in Miles Per Hour (V_{max})			
0° 10'	0.17	90	90	90	90
0° 20'	0.33	90	90	90	90
0° 30'	0.50	90	90	90	90
0° 40'	0.67	90	90	90	90
0° 50'	0.83	90	90	90	90
1° 00'	1.00	90	90	90	90
1° 15'	1.25	82	84	86	87
1° 30'	1.50	75	77	78	80
1° 45'	1.75	69	71	72	74
2° 00'	2.00	65	66	68	69
2° 15'	2.25	61	62	64	65
2° 30'	2.50	58	59	60	62
2° 45'	2.75	55	56	58	59
3° 00'	3.00	53	54	55	56
3° 15'	3.25	51	52	53	54
3° 30'	3.50	49	50	51	52
3° 45'	3.75	47	48	49	50
4° 00'	4.00	46	47	48	49
4° 15'	4.25	44	45	46	47
4° 30'	4.50	43	44	45	46
4° 45'	4.75	42	43	44	45
5° 00'	5.00	41	42	43	43
5° 30'	5.50	39	40	41	41
6° 00'	6.00	37	38	39	40
6° 30'	6.50	36	37	37	38
7° 00'	7.00	34	35	36	37
7° 30'	7.50	33	34	35	35
8° 00'	8.00	32	33	34	34
8° 30'	8.50	31	32	33	33
9° 00'	9.00	30	31	32	32
9° 30'	9.50	30	30	31	31
10° 00'	10.00	29	29	30	31
10° 30'	10.50	28	29	29	30
11° 00'	11.00	27	28	29	29
11° 30'	11.50	27	27	28	28
12° 00'	12.00	26	27	27	28
12° 30'	12.50	26	26	27	27
13° 00'	13.00	25	26	26	27
13° 30'	13.50	25	25	26	26
14° 00'	14.00	24	25	25	26
14° 30'	14.50	24	24	25	25
15° 00'	15.00	23	24	24	25

(1) In degrees and minutes
(2) In decimals

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	**Degree Curve (D)[2]**	**Superelevation in inches (E_a)**			
		4	**4-1/4**	**4-1/2**	**4-3/4**
		Speed in Miles Per Hour (V_{max})			
0° 10'	0.17	90	90	90	90
0° 20'	0.33	90	90	90	90
0° 30'	0.50	90	90	90	90
0° 40'	0.67	90	90	90	90
0° 50'	0.83	90	90	90	90
1° 00'	1.00	90	90	90	90
1° 15'	1.25	89	90	90	90
1° 30'	1.50	81	83	84	85
1° 45'	1.75	75	76	78	79
2° 00'	2.00	70	71	73	74
2° 15'	2.25	66	67	69	70
2° 30'	2.50	63	64	65	66
2° 45'	2.75	60	61	62	63
3° 00'	3.00	57	58	59	60
3° 15'	3.25	55	56	57	58
3° 30'	3.50	53	54	55	56
3° 45'	3.75	51	52	53	54
4° 00'	4.00	50	50	51	52
4° 15'	4.25	48	49	50	51
4° 30'	4.50	47	47	48	49
4° 45'	4.75	45	46	47	48
5° 00'	5.00	44	45	46	47
5° 30'	5.50	42	43	44	44
6° 00'	6.00	40	41	42	42
6° 30'	6.50	39	39	40	41
7° 00'	7.00	37	38	39	39
7° 30'	7.50	36	37	37	38
8° 00'	8.00	35	35	36	37
8° 30'	8.50	34	34	35	36
9° 00'	9.00	33	33	34	35
9° 30'	9.50	32	33	33	34
10° 00'	10.00	31	32	32	33
10° 30'	10.50	30	31	31	32
11° 00'	11.00	30	30	31	31
11° 30'	11.50	29	30	30	31
12° 00'	12.00	28	29	29	30
12° 30'	12.50	28	28	29	29
13° 00'	13.00	27	28	28	29
13° 30'	13.50	27	27	28	28
14° 00'	14.00	26	27	27	28
14° 30'	14.50	26	26	27	27
15° 00'	15.00	25	26	26	27

(1) In degrees and minutes
(2) In decimals

Table 1.
Maximum Allowable Operating Speed on Curves
Underbalance = 3" (E_u)

Degree Curve (D)[1]	Degree Curve (D)[2]	Superelevation in inches (E_a) 5	5-1/4	5-1/2	5-3/4	6
		Speed in Miles Per Hour (V_{max})				
0° 10'	0.17	90	90	90	90	90
0° 20'	0.33	90	90	90	90	90
0° 30'	0.50	90	90	90	90	90
0° 40'	0.67	90	90	90	90	90
0° 50'	0.83	90	90	90	90	90
1° 00'	1.00	90	90	90	90	90
1° 15'	1.25	90	90	90	90	90
1° 30'	1.50	87	88	89	90	90
1° 45'	1.75	80	82	83	84	85
2° 00'	2.00	75	76	77	79	80
2° 15'	2.25	71	72	73	74	75
2° 30'	2.50	67	68	69	70	71
2° 45'	2.75	64	65	66	67	68
3° 00'	3.00	61	62	63	64	65
3° 15'	3.25	59	60	61	62	62
3° 30'	3.50	57	58	58	59	60
3° 45'	3.75	55	56	56	57	58
4° 00'	4.00	53	54	55	55	56
4° 15'	4.25	51	52	53	54	55
4° 30'	4.50	50	51	51	52	53
4° 45'	4.75	49	49	50	51	52
5° 00'	5.00	47	48	49	50	50
5° 30'	5.50	45	46	46	47	48
6° 00'	6.00	43	44	44	45	46
6° 30'	6.50	41	42	43	43	44
7° 00'	7.00	40	41	41	42	42
7° 30'	7.50	39	39	40	40	41
8° 00'	8.00	37	38	38	39	40
8° 30'	8.50	36	37	37	38	38
9° 00'	9.00	35	36	36	37	37
9° 30'	9.50	34	35	35	36	36
10° 00'	10.00	33	34	34	35	35
10° 30'	10.50	32	33	34	34	34
11° 00'	11.00	32	32	33	33	34
11° 30'	11.50	31	32	32	32	33
12° 00'	12.00	30	31	31	32	32
12° 30'	12.50	30	30	31	31	32
13° 00'	13.00	29	30	30	31	31
13° 30'	13.50	29	29	29	30	30
14° 00'	14.00	28	29	29	29	30
14° 30'	14.50	28	28	28	29	29
15° 00'	15.00	27	28	28	28	29

(1) In degrees and minutes
(2) In decimals

Moving Massachusetts Forward. massDOT Rail & Transit

APPENDIX C

GLOSSARY

APPENDIX C

GLOSSARY

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

Page

TABLE OF CONTENTS
(Continued)

Page

TABLE OF CONTENTS
(Continued)

APPENDIX C

GLOSSARY

- A -

Adjusting/De-stressing
The procedure by which a rail's temperature is re-adjusted to the desired neutral temperature range. It typically consists of cutting the rail and removing rail anchoring devices, which provides for the necessary expansion, and then re-assembling the track.

Alignment – General
The physical appearance of the railroad as viewed from above, which consists of a series of straight lengths of track, referred to as tangents and spirals, connecting simple, compound or reverse curves.

Alignment-Line
The condition of track in regard to uniformity of direction over short distances on tangents and in curves.

Aggregate
The sand, gravel, broken stone or combinations thereof with which the cementing material is mixed to form a mortar or concrete. The fine material used to produce mortar for stone and brick masonry and for the mortar component of concrete is commonly termed "fine aggregate," while the coarse material used in concrete only is termed "course aggregate."

- B -

Ballast
Select material placed on the roadbed to support and hold track in line and surface. Ballast preferably consists of sized hard particles that distribute the load, drains well and maintains proper line and surface.

Ballast Cleaning
The process of separating contaminants from the ballast by shaking and then depositing stone back onto the track.

Ballast Section
The cross section of a track between and under the crossties and between the ballast shoulders.

Ballast Shoulder
The portion of ballast between the end of the tie and the bottom of the ballast slope. It distributes the traffic load over a greater width of roadway and helps hold the track in alignment by providing lateral resistance.

Bar - Joint
Bars that are used to physically connect two rail ends and ensure proper rail head and gage face alignment. Also called a joint bar.

Batter - Rail
Deformation of the surface of the rail head, usually close to the end of the rail, caused generally by wheel impact loads.

Braking Force
The longitudinal and lateral force induced into the rail as a result of the brake application of a train.

Bridge - Ballast Deck
A bridge with a solid floor provided with drains and covered with ballast to provide uniform support for track.

Bridge Timber
A sawed tie usually pre-framed on all four sides and of the size and length required for track on an open deck bridge.

Buckling Incident
The formation of a lateral misalignment sufficient in magnitude to cause a general instability of track which may constitute a deviation from Class requirements specified in §213.55 of Part I. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

- C -

Cant
Tilt or inclination of the base of the rail. Canting of the rail is achieved with the use of a tie plate or rail seat designed to cant the rail inward towards the center-line of track and should be installed accordingly. Typical cant is 1:40.

Clip
An elastic fastener that is applied parallel or perpendicular to the base of the rail and replaces and eliminates the need for a cut spike and anchor. A clip can be used on wood or concrete ties.

Clip - Switch
The device by which the switch rod is joined to the switch points. It is normally connected to the switch points by bolts protected by cotter keys or pins. It sometimes has staggered bolt holes in the horizontal leg for making detailed adjustments in the positions of the switch points.

Closure Rail
The lead rails connecting the heel end of the switch with the toe ends of a frog.

Coefficient of Thermal Expansion – Rail
A multiplier based on the physical properties of rail steel used to calculate the change in rail length with change in temperature. The coefficient is 0.000078 when the length of the rail is in feet.

Compression
A uniform axial force within the rail caused by equal and opposite forces pushing at the ends of the rail.

Compromise Joint Bar
See Joint Bar – Compromise

Continuous Welded Rail (CWR)
Rail that has been welded together into lengths exceeding 400 feet. See Part I, §213.119.

Crossing – At Grade (Highway)
A crossing or intersection of a railroad and a highway at the same level or grade.

Crossing – At Grade (Track)
A structure, used where one track crosses another at grade, which consists of four connected frogs. Crossing angles can be defined as:

Low angle:	Up to and including 30°
Medium angle:	31° to 60°
High angle:	61° to 90°

Crosslevel
The difference in elevation between the rails at the same location.

Crossover
Two turnouts with the track connected at their frogs, arranged to form a passage between two nearby and generally parallel tracks.

Curvature - Degree of
A measure of the sharpness of a simple curve where a 1" offset at the mid-point of a 62' chord is equal to 1°.

Curve - Compound
A curve composed of two or more simple curves that are joined by easement spirals and that lead in the same general direction (i.e., to left or right, but each with different radii).

Curve - Reverse
A curve composed of two simple curves that are joined by a common tangent point or by a short tangent track which bear in opposite directions.

Curve - Simple (Horizontal)
A curve in the form of a circular arc that is bounded by two tangents. By definition these curves do not have spirals and may be found in yards and on secondary track.

Curve - Vertical
A curve in the profile of a track to connect intersecting grade lines and to permit safe and smooth operation of trains over summits and across sags.

- D -

Derail
A track device to guide rolling stock off the rails at a selected spot and divert the rolling stock away from the track that is being protected. Derails provide protection against collisions or side swipes. Derails are generally of three kinds: the “split switch,” the “sliding block,” and the “hinged block” type.

Derailment
Anytime a wheel of a car or engine comes off the head of the rail.

Desired Rail Installation Temperature Range (DRTR)
The rail temperature range, within a specific geographical area, at which forces in CWR should not cause a buckling incident in extreme heat, or a pull apart during extreme cold weather. Definition from FRA Part 213, §213.119(g).

Deviation
Difference between a design or published standard and actual measurement at any one location.

Disturbed Track
The disturbance of the roadbed or ballast section, as a result of track maintenance or any other event, which reduces the lateral and longitudinal resistance of the track.

Dynamic Train Loading
Vertical, horizontal and longitudinal forces that are imparted to the track structure during the passing of a train due to wheel action and vehicle response.

- E -

Elastic Rail Fastener
A rail hold down system that secures the running rail to wood or concrete ties and/or a concrete slab. The fastener uses rail clips and a base plate with or without resilient pads. This system provides lateral, longitudinal and vertical rail restraint during the passage of trains. (See additional information under “Rail Fastening System.”)

Engine Burn
Damage to the rail head metal caused by slipping or “spinning” powered wheels. Engine burn fracture is a rail break caused by an engine burn.

Expansion Joint
A device that allows thermal movement in rail to be relieved by allowing the rail on one side of the joint to freely expand and contract. Often installed on the approaches to moveable bridges so that thermal forces and movements in continuous welded rail adjacent to the bridge cannot be transferred into the bridge or the miter rail assembly, where it could jam and prevent needed movement.

- F -

Facing Point
A facing point move is one where the rail vehicle moves over the switch points and then the frog.

Federal Railroad Administration (FRA)
A government agency in the U.S. Department of Transportation.

Fishing Space
Space between the head and base of a rail occupied by a splice bar (angle bar, joint bar).

Flangeway
Measured space between running rail, guard rail, frog casting, frog wing rail and road crossing to provide clearance for passage of wheel flanges.

Flow of Metal (Rail)
Deformation of the top of the rail head on the crown of a rail toward the gage or field side. Common on the low side of a curve where trains run at less than balanced speed.

Fracture – Detail
A progressive transverse fracture originating in the head of a rail.

Frog
A device used where two running rails intersect, with flangeways to permit wheels and wheel flanges on either rail to cross one another.

Frog – 1/2" Point
The 1/2" point of frog is the point at which the spread between gage lines is 1/2". All measurements in the field are usually made from the 1/2" point of frog.

Frog – Railbound Manganese (RBM)
A frog assembly that consists of wing rails surrounding a manganese casting with a rigid frog point and flangeways. A conventional guard rail is used with this type of frog.

Frog – Self-Guarded (SGM)
A frog with a guard member for guiding the flange of a wheel past the point of frog by engaging the tread rim of the wheel in a horizontal plane above the top of the running surface of the frog. This makes a conventional guard rail unnecessary.

Frog – Spring
An appliance that contains, among other things, a fixed frog point, a moveable spring wing rail, a rigid wing rail, frog hold-down assemblies, and spring box. The frog makes use of a long guard rail (on the straight side). The spring frog design provides a continuous bearing surface for the wheel tread as it traverses through the frog point area on the straight side of the turnout.

Frog – Theoretical Point
The theoretical point of the intersection of the gage lines. The theoretical frog point is at a distance, in inches, ahead of the 1/2" point which is equal to one-half the frog number (i.e., number 10 frog is 5").

Frog – Throat of
Point at which the converging wings of a frog are closest together.

Frogs – End
The two frogs at the opposite ends of the long diagonal of a crossing or slip.

Frog Angle
Angle formed by intersecting gage lines of the rails in a frog.

Frog Number
The frog angle expressed as the number of units of centerline length in which the spread is one unit (i.e., 10:1 is a number 10 frog).

- G -

Gage Line
A line 5/8" below the running surface of a rail on the side of the head nearest the track center. The line from which measurements of gage are made.

Gage of Track
Distance between gage lines of rails laid in track.

Gage Rod
A device for holding track to correct gage, generally consisting of 1-1/4" rod with a forged jaw on one end and a malleable jaw on the other end, adjustable through a locknut. Sometimes consists of a rod made in two parts with a solid jaw on each end, united by a turnbuckle.

Gaging of Track
Bringing the rail heads of a track into their correct distance apart.

Grade
Rate of rise or fall of the grade line, expressed as a percentage of the feet of rise or fall per 100' of length. A steady rise or fall of 1' per 100' is a 1% grade.

Grade Line
The line representing top-of-rail elevations and the profile of the track.

Grade Rail
The rail first surfaced to track elevation; the line rail on tangents, the inner or low rail on curves.

Guard Rail - Frog
A rail section assembly used in a turnout with a railbound manganese (RBM) frog, spring rail frog, or in track crossings. The guard rail is designed to guide the wheel set through the proper flangeway of the frog. The guard rail prevents the wheel flange from wearing, striking or picking the frog point.

Guard Rail – Inner Track
An additional rail or rails laid parallel to and between the running rails of bridges, bridge approaches, and at other critical locations to prevent derailed equipment from striking a bridge or other structure and to keep the derailed wheels on the ties of the bridge.

Guard Rail – Outer Track
Additional timber laid parallel to the running rails of long-span viaducts.

- H -

Head Block - Switch
Ties used to support the switch-point operating mechanism (powered or unpowered) and the switch stand.

Head or No. 1 Rod
The switch rod nearest the point of a switch, usually placed between the two head block ties.

Heel Block - Fixed
A rigid heel block assembly at the switch heel to maintain the proper horizontal heel spread between the switch rail and stock rail. The heel block limits the amounts of longitudinal movement between the switch point and stock rail. The heel block is bolted to the switch rail and stock rail.

Heel Block - Floating
An assembly at the switch heel to maintain the proper horizontal heel spread between the switch rail and stock rail. If the assembly is bolted to the switch rail only, the switch heel "floats" and is called a floating heel block.

Heel Length - Frog
Distance between the heel end and half-inch point of a frog measured along gage lines.

Heel of Frog
The end of a frog farthest from the switch point.

Heel of Switch
The end of the switch where the switch point connects to the closure rails (see Heel Block – Fixed and Floating). The heel of the switch can be either fixed to the stock rail or allowed to float freely.

Heel Spread - Frog
Distance between gage lines at the heel end of a frog.

Heel Spread - Switch
The distance between the gage lines of the stock rail and switch rail at the heel of the switch.

Highway-Crossing Warning Devices (Active)
An arrangement of one or more highway-crossing signals, with or without gates at a highway grade crossing.

- I -

Interlockings
An arrangement of signals, switch locks, and signal appliances so interconnected that their movements succeed each other in a predetermined order. It may be operated manually or automatically.

- J -

Joint Bar
A steel angle bar or other shape used to fasten together the ends of rails in a track. They are used in pairs and are designed to fit the space between head and base of rail (fishing space) closely. They are held in place by track bolts. Also called angle bar, rail joint bar and splice bar.

Joint Bar – Compromise
A special rail joint, sometimes called a step joint, for joining rails of different sections. The joint is made so that it brings gage faces and rail heads into line so that a continuous smooth surface is present for the treads and flanges of passing wheels. The hand of a compromise joint is designated by standing in the gage of track at the small rail section looking or facing towards the heavier rail section to be joined or compromised. In this location in track, the right hand compromise joint is on the right and left hand is on the left. A compromise joint is described by indicating the heavier rail section and then the light rail section to be compromised (i.e., 136/115).

Joint – Frozen
A joint so tight that the rails cannot move within the joint bar as temperature varies.

Joint – Insulated
A rail joint designed to prevent the flow of electric current from rail to rail by means of insulation so placed as to separate the rail ends and other connecting metal parts at the joint.

Joints – Supported and Suspended
A supported rail joint has a tie directly under the rail ends. A suspended joint is one in which ends of the rail joint are not resting on a tie.

Joint Tie
A cross tie used under a rail joint.

- L -

Latch - Switch Stand
A device for catching and holding the lever of switch stand in position, also called a switch keeper. Two latches are used at each switch stand.

Lateral Acceleration
The horizontal acceleration experienced by a rail vehicle that is perpendicular to the direction of travel. Lateral acceleration is a measure of ride quality and measured in units of ft./sec^2(g).

Lateral Resistance
The ability of the track structure to remain in position under the influence of in-service forces that are generated in a plane perpendicular to the line of the rail. Lateral resistance is a product of interaction of the ballast with the sides, bottom and end face of the tie.

Lead (Conventional)
The length between the actual point of switch and the 1/2" point of frog, measured on the line of the straight track.

Lead – Theoretical (Tangential)
The length between the actual point of switch and the theoretical point of a moveable point frog, measured on the line of the straight track.

Level Board
A tool used to determine the cross-level or super elevation of a track.

Lift Rail
The portion of a miter rail assembly that is attached to the moveable span of a moveable bridge. Sometimes called the bridge rail or moveable rail.

Line
The condition of a track in regard to uniformity in direction over short distances on tangents or uniformity in variation in direction over short distances on curves.

Line Rail
The rail on which alignment is based; the east rail of tangent track running north and south, the north rail of tangent track running east and west, the outer rail on curves, or the outside rails in multiple track territory.

Lining Track
Shifting the track laterally to conform to an established alignment. Maintenance lining is ordinarily done during repairs. Lining is done to make the track conform to predetermined alignment.

Longitudinal Resistance
The ability of the track structure to remain in position under the influence of train and temperature forces that run parallel with the rail. Longitudinal resistance is a product of the interaction of the ballast, the tie, rail anchors, rail clips and other elastic fasteners.

L/V Ratio
The relationship of lateral force on the rail to the vertical force on the rail, which is produced by the wheel of railroad rolling stock, locomotives, work equipment and other equipment moving along the track.

- M -

Maximum Authorized Speed (MAS)
That maximum speed for a portion of track as specified in the current Employee's Timetable.

Mechanical Stabilization
A procedure used to restore lateral and longitudinal stability of disturbed track following maintenance operations. This procedure may incorporate dynamic track stabilizers which are units of work equipment that are used as a substitute for the action provided by the passage of tonnage trains.

Middle Ordinate
The distance measured from gage line of rail to the middle of a string drawn taut and held to contact with the gage line of rail at its end. The middle ordinate provides a means of measuring curvature. Can also be used in bending rails to a desired curvature.

Miter Rail
A rail assembly on a moveable bridge that spans the gap between the moveable span and the adjacent stationary portion of the bridge. The miter rail typically consists of two pieces. One rail is stationary or fixed and attached to the non-moving portion of the bridge and the second rail is attached to and moves with the moving portion of the bridge.

The term miter is used because typically the abutting ends of the two portions of the miter rail assembly, rather than being cut square as in a conventional rail joint, are cut at an acute angle or "mitered" relative to each other. The miter can provide the wheels with continuous support over the rail gap.

Because one rail must be able to move relative to the other when the bridge is being opened, the abutting ends of the miter rail assembly are not bolted to each other as in a conventional rail joint, but rather sit in bed plates that align one end of the miter rail relative to the other.

Moveable Bridge
Any bridge span over a navigable waterway that can be moved to accommodate the passage of vessels taller than the normal underclearance of the bridge.

- N -

Neutral Temperature
The temperature at which rail is secured in a stress-free condition.

Neutral Temperature Management (See Appendix A)
Maintaining the condition of the track structure so that the neutral temperature of the rail remains within the acceptable neutral temperature range.

Number - Turnout
The number corresponding to the number of the frog used in a turnout.

- O -

Out-of-Face Surfacing or Lining (See Appendix A)
The continuous surfacing and/or lining of a piece of track greater than 200' in length.

Out-of-Face Tie Renewal (See Appendix A)
Tie replacement at the rate of more than six (6) ties per 39' of rail. Not more than two (2) consecutive ties nor more than six (6) ties per 39' of rail can be replaced in any one pass.

Out-of-Face Undercutting (See Appendix A)
Undercutting of more than two (2) consecutive ties or more than six (6) ties in 39' of track.

- P -

Post – Bumping
A device at the end of stub track to prevent rolling stock from going off the ends of the rails.

Preferred Rail Laying Temperature (PRLT)
The desired temperature (i.e., 95ºF) at which continuous welded rail (CWR) is to be laid. The PRLT is region-specific and is the temperature at which there will be no stress in the CWR.

Profile
A longitudinal section through a track that shows elevation of the grade rails. The profile is usually obtained from levels taken on top of the rail.

- R -

Rail - High
The outer or elevated rail of a curved track, which is maintained as the line rail.

Rail - Low
The inner rail of a curve which is maintained as the grade rail.

Rail – Nervous Track
CWR which exhibits minute alignment irregularities which indicate that the rail is in a considerable amount of compression.

Rail - Scrap
Rails of standard section not fit for use as relayer rail.

Rail Anchors
Those devices which are attached to the base of the rail and bear against the side of the crosstie to control longitudinal rail movement. Certain types of rail fasteners also act as rail anchors and control longitudinal rail movement by exerting a downward clamping force on the upper surface of the rail base.

Rail Bender
A tool for bending stock rails.

Rail Bond
A device used to transfer an electric circuit across rail ends at a rail joint or discontinuity in the rail.

Rail Brace
A device used at switches, moveable-point frogs, guardrails, etc., in combination with switch, tie or gage plates, for holding rail in place in the plate and preventing lateral displacement.

Rail Brand
An identification mark, including manufacturer's name or initials, month and year the rail was rolled, manufacturer's identification label, weight per lineal yard, initials of section, number of the heat, portion of the ingot and process of manufacture.

Rail Fastening System
The hold-down appliances that provide the required combination of horizontal, lateral and vertical restraint to permit the safe operation of rail vehicles. Examples of conventional systems found include the cut spike and rail anchor. Examples of elastic fastening systems include the Pandrol "e" clip, fast clip with a pin (lock spike) or lag screw.

Rail Joint - Pumping
A poorly supported rail joint that has excessive up and down movement under the passage of trains.

Rail Section
The pattern of dimensional details of rail, such as width of base, height of rail, thickness of web, width and thickness of head, angle of head and angle of base. Each particular pattern is identified by a brand name or symbol, such as ASCE, AREA, ARA, PRR, PS, etc., in addition to its weight per yard.

Rail Stretcher Expander
A rail puller/expander operated by hand or by machine that is used to increase or decrease the gap between adjoining rail ends.

Rail Temperature
The temperature of the rail, measured with a rail thermometer on the shaded side of the web.

Rail Weight
The weight of a three (3) foot-long section of rail expressed in pounds per yard.

Relay Material
Useable secondhand rail, ties or other track material (OTM).

Roadbed
The finished sub-grade surface upon which the track and ballast rest.

Rod - Operating
A rod attached to a switch, derail, or other device, for moving it from one position to another. The operating or throw rod can be reset to adjust the amount of throw occurring at the switch.

Running Rail
The rail or surface on which the wheel bears.

Runoff - Curve
The change in superelevation in the spiral/easement from the full body of a curve to tangent or between compound curves.

Runoff - Surface
An area of grade change in track where the raised portion of a track is connected with the existing grade. The runoff between the two elevations is made along the two rails at a designated rate of change per 31' station for comfort and safety.

- S -

Scrap
Rail, ties or other track materials (OTM) that are not suitable for reuse.

Screw - Lag
A cylindrical threaded steel spike with a square head designed to be turned with a special appliance into holes bored into ties.

Shim - Track
A bearing piece, usually wood or metal of various thickness, at least equal to the width and length of the tie plate, for temporary use between the tie plate and ties to raise (surface) the rail to a desired relative elevation. Usually used to spot surface a track when the roadbed is frozen and the ties cannot be tamped and surfaced.

Side Planing - Undercutting
Cuts made on sides of the head of the switch rail to form a taper from the full width of the head to the switch point. Also used in a stock rail to match undercut switch points.

Spot Surfacing (See Appendix A)
Surfacing a piece of track up to 200' in length.

Spot Tie Renewal (See Appendix A)
The installation of six (6) or less ties per 39' of rail with no more than two adjacent ties replaced in a row. The new ties must be promptly tamped and the ballast properly dressed.

Stock Rail
The two running rails that support the operation of the switch points. The straight stock rail is on the straight side of a lateral turnout The bent stock rail or curved rail is on the diverging side of the turnout. The switch points fit securely against or are undercut into the stock rail to permit the transfer of wheel load from the stock rail to the switch point. An equilateral turnout has two straight stock rails.

Stock Rail Bend
The bend or set that must be given the stock rail to allow the switch point to follow the gage line through the turnout. Usually, the stock rail on the diverging side of a turnout is bent. The opposite stock rail is straight .

Stringlining
A method for determining the alignment of a curve, by measuring mid-ordinates to the outer rail with string and paddles.

Sub-ballast
Any approved granular material which is placed between the ballast and finished sub-grade of the roadbed, to provide distribution of the load to the roadbed, better drainage, and prevent upheaval of the sub-grade by frost.

Sub-grade
The top of natural materials, gravel or crushed rock, usually inferior to ballast or sub-ballast, placed in fills or at the bottom of cuts that lie directly below the sub-ballast and ballast.

Superelevation – Equilibrium
The elevation of the outer rail which balances the centrifugal forces while negotiating a curve at a given design speed.

Superelevation
The height at which the outer rail is raised above the inner or grade rail on curves to resist the centrifugal force of moving trains.

Switch
A connection between two lines of track to permit flange wheeled rail vehicles to pass from one track to another.

Switch – Insulated
A switch in which the fixtures, principally the gage plates and the switch rods connecting one rail to the other, are provided with insulation so that electric currents will not be shunted.

Switch – Spiked/Clamped
A switch point that is secured in one position through the use of spikes, blocks and clamps.

Switch – Throw of
The distance measured between the switch point and stock rail at the point of switch.

Switch Heater
A device for melting snow with heat generated by an electric current, gas or propane. This device enables a switch which is so equipped to be thrown in inclement weather when there are accumulations of sleet, ice or snow.

Switch Lock
A fastener, usually a spring padlock used to secure the switch or derail stand in place.

Switch Machine
The signal appliance that powers and provides for the positive movement and locking of the switch points and/or moveable point frog to permit the safe, uninterrupted movement of rail vehicles through a turnout.

Switch Machine Rod Basket
The appliance that connects the operating rod to the No. 1 tie rod in the switch or to the frog point lug of a moveable point frog

Switch Obstruction Test
This test is used as part of the criteria to determine if the switch points in signal territory are properly fitting up against the straight and bent stock rails or if the moveable point of a moveable point frog fits against the moveable point frog housing. This test ensures that the proper signal indication is being conveyed as the points move and are seated.

Switch Plate
A special metal tie plate for use on switch ties, each plate being long enough to extend not only under the stock rail and its supporting braces, but also under the switch point in the open position. Switch plates are furnished in sets to correspond with switch length. There are two plates to each tie. However, at the point of switch and at helper locations, the two plates may be replaced by a gage plate(s) that carries both switch points. A type of high-profile switch plate used in some turnouts which contain two elastic clips to secure the stock rail to the switch plate.

Switch Point
The moveable rail of a switch which determines the direction of train movement.

Switch Point – Undercut
A switch point that is planed on the field side to fit securely against an undercut stock rail.

Switch Point Guard
A structure made of rail or manganese steel secured to the field side of the running rail at the point of switch, with suitable flares to engage the tread rims of wheels and guide the wheel past the switch point. This appliance is intended to reduce or eliminate switch point contact and wear. This appliance is to be used where operating speeds are 15 mph and less.

Switch Point Lug (Clips)
The lug attached to a switch point, to which the front rod is connected.

Switch Point with Graduated Risers
A switch in which the switch points are gradually elevated by means of graduated riser plates, until they reach the required height above a stock rail and sloping back to zero at the fixed heel block.

Switch Point with Uniform Risers
A switch in which the switch points have a uniform elevation on riser plates for the entire length of the switch, and therefore do not have a heel slope. The switch point rail rise is run off in back of the floating heel block.

Switch Rod
The rods that connect the left hand and right hand switch point to ensure proper gage, alignment and adjustment throughout the switch.

Switch Stand
A manually operated device by which a switch is thrown, locked, and its position indicated. It consists essentially of a base, spindle, lever, connecting rod and target.

Switch Target
A signal placed adjacent to or fixed on the spindle of a switch stand with reflective materials indicating the position of the switch.

- T -

Tension
An axial force caused by equal and opposite forces pulling at the ends of the rail.

Thimble (Insulated Joints)
The cylindrical pieces of an insulating joint that surround portions of the bolts.

Throat of Frog
The point at which the converging wing rails of a frog are close together just ahead of frog point.

Tie
A transverse support to which rails are fastened to keep them in line, gage and grade. Usually wooden or concrete.

Tie - Centerbound
Ballast condition where an unusually large percentage of the wheel load is carried at the center of the tie. This is an undesirable situation as compacted ballast under the rail seats should carry the load.

Tie Plate
A metal plate at least 6" wide and long enough to provide a safe bearing area on the tie, with a shoulder to restrain lateral movements of the rail.

Tie Plate - Twin
A tie plate in two parts that mate to form a combined width equal to that of the stand tie plate, for use back of the heel of switch to the point where standard tie plates may be applied.

Tie Plug
A wooden plug driven in to fill an unused spike hole or lag hole in a tie, to exclude moisture, prevent decay, and provide solid wood for re-driving of the spike. Usually supplied in the form of sticks containing several plugs.

Tie Spacing
The distances between tie centers in track or turnouts.

Toe End of Frog
The end of a frog nearest the switch.

Toe Spread
The distance between gage lines at the toe end of the frog.

Track
The rail, ties, rail fastenings, hardware and roadbed between points not less than 4' outside of each rail.

Track Buckling
The sudden formation of large lateral misalignments caused by high compressive forces, in the presence of some other influencing factors.

Track Lateral Resistance
The resistance provided to the rail/crosstie structure against lateral displacement.

Track Longitudinal Resistance
The resistance provided by the rail anchors/rail fasteners and the ballast section to the rail/crosstie structure against longitudinal displacement.

Track - Skeletonized
Track with ballast removed from the cribs between ties.

Track Spike (Cut Spike)
A rectangular metal fastener with an elliptical head designed to secure tie plates and/or rail to wood ties and timber.

Track - Surface
The condition of the track structure as to vertical evenness or smoothness.

Tractive Force
The longitudinal force induced into the rail as a result of the tractive effort exerted by the powered axles of rail vehicles.

Trailing Point
A trailing point move would pass over the frog and then the switch points.

Train-induced Forces
The vertical, longitudinal and lateral dynamic forces which are generated during train movement.

Transition Rail
A rail that joins two rails of different sections. It consists of two different rails flash butt welded to a middle forged section of rail. This rail is used in place of compromise bars.

Transition Spiral
An easement curve from the tangent to the curve.

Transpose Rail
Changing rail from one side to the other on curves because of headwear.

Turnout (TO)
An arrangement of a switch and a frog with closure rails, by which rolling stock can be diverted from one track to another.

Turnout (Premium Design)
A turnout that contains premium materials such as fully heat treated rail with elastic fasteners on wood and/or concrete ties. The design of premium turnouts may incorporate such things as tangential geometry, asymmetrical switch points and moveable point frogs or spring frogs.

Turnout – Conventional
A turnout whose transition from tangent to curve is abrupt because of alignment changes between the switch point and frog. These turnouts are usually constructed on wood ties, but can also be constructed on concrete ties. These turnouts usually have a “tee” rail switch point section and a self-guarded manganese (SGM) frog or railbound manganese (RBM) frog.

- U -

Underbalance
The difference between the actual superelevation and the amount of superelevation calculated for equilibrium conditions. Design underbalance on the MassDOT operated railroads is 1-1/2".

- W -

Washer – Spring (Lock)
A spring tensioned member designed to prevent movement of a nut and the loosening of a bolted member due to wear, stretch or other deterioration.

Weld – Flash Butt
A butt weld joining two abutting rails. This weld serves to join the rail ends using only parent materials. Electric flash_butt rail welding is accomplished with a stationary or portable electrical plant.

Weld - Thermite
A weld joining two abutting rails. The weld serves to unite the abutting rails with the introduction of metal weldment into a preset gap. This is an alumnothermic process that is accomplished by using weld kits..

Wheel Tread
The flat or tapered surface of a railway wheel that contacts the top surface of the rail head.

Wing Rail
The left and right rails that are run from the toe to the flared end of a moveable point frog, railbound manganese frog (RBM) or spring frog.

APPENDIX D

PLACEMENT OF TEMPORARY SPEED SIGNS

APPENDIX D

PLACEMENT OF TEMPORARY SPEED SIGNS

1.0 TEMPORARY SPEED RESTRICTION

(a) Protection shall be provided for any track that is considered not satisfactory for the passage of trains at maximum authorized speed, including placing an appropriate temporary speed restriction and notification to the Train Dispatcher.

(b) Portions of Tracks, on which temporary speed restrictions have been placed, are to be marked by placing a reflectorized Advanced Speed Limit sign, and Speed Limit and Resume Speed signs to the right of each track for both directions of traffic.

  (1) The general arrangement, details of construction and assembly, height and distance from the track, of signs, shall be as shown on the following plans.

  (2) Signs are to be placed so as to give the greatest practical unobstructed view considering alignment and other local physical conditions. Reflecting surfaces of signs must be kept clean to preserve their reflecting ability.

  (3) Speed Limit and Resume Speed signs are to be placed with the Speed Limit sign at the point where the actual restriction begins and the Resume Speed sign at the point where it ends.

  (4) Advanced Speed Limit signs, with numerals indicating the speed restriction, are to be placed far enough ahead of the Speed Limit signs in the direction from which trains are approaching to permit trains to reduce from normal speed to the speed permitted by the restriction.

(c) When a condition arises requiring a speed restriction, the following must be done:

  (1) Notification must be given to the dispatcher governing movement on the track where restriction is required.

  (2) Notification must be given to Track Supervisor.

  (3) Notification must include:

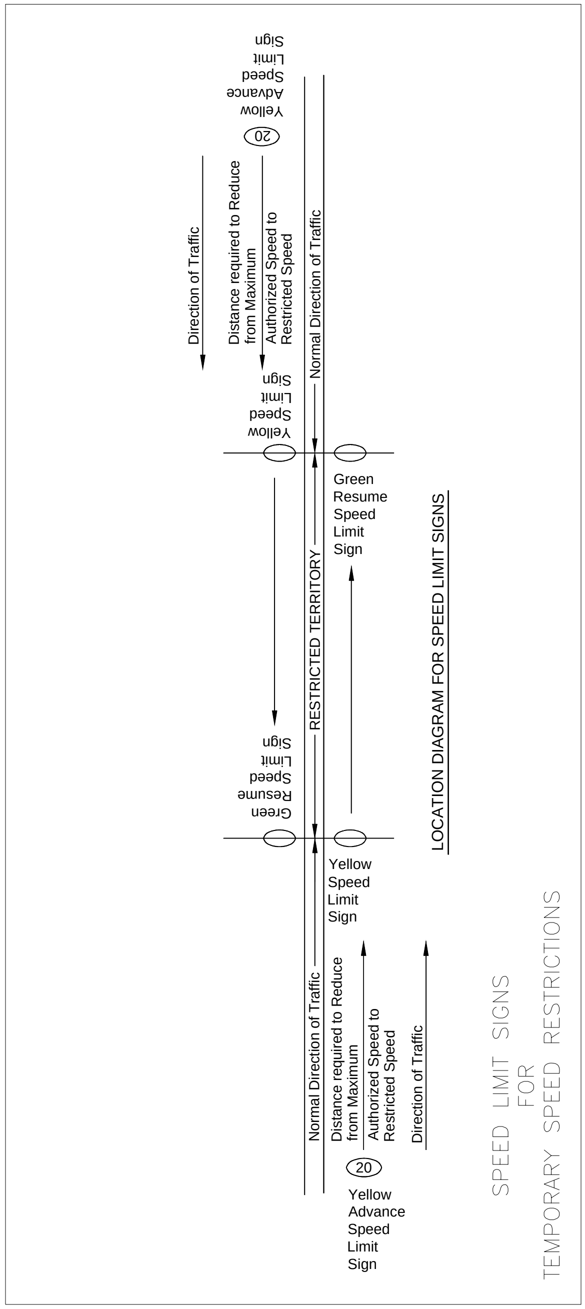
    (i) Limits of restriction by milepost station.

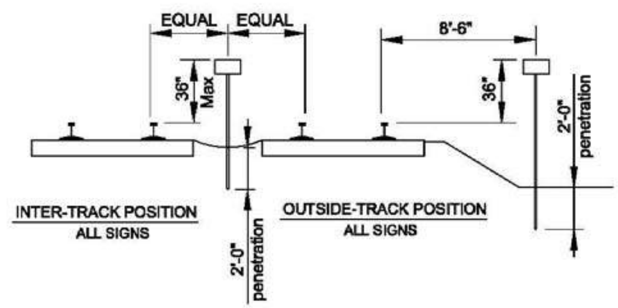
    (ii) Speed to which track is restricted.

    (iii) Reason for restriction.

    (iv) Action being taken to correct condition.

  (4) Immediate action must be initiated to remove restriction.


SPEED LIMIT SIGNS FOR TEMPORARY SPEED RESTRICTIONS
LOCATION DIAGRAM FOR SPEED LIMIT SIGNS
RESTRICTED TERRITORY
Normal Direction of Traffic
Direction of Traffic
Distance required to Reduce from Maximum Authorized Speed to Restricted Speed
20
Yellow Advance Speed Limit Sign
Yellow Speed Limit Sign
Green Resume Speed Limit Sign



SPEED LIMIT SIGNS
FOR
TEMPORARY SPEED RESTRICTIONS

Note:
Where local conditions make it desirable, the Resume Speed Sign and The Speed Limit Sign may be mounted back to back on the same support

Temporary Speed Limit Signs
Advance Speed Limit sign with numerals indicating restricted speed shall be placed a sufficient distance in advance of restricted territory to permit a train to reduce from maximum authorized speed to the restricted speed.

Speed Limit sign shall be placed to mark the entrance to the restricted territory.

Resume Speed sign shall be placed to mark the end of restricted territory. When entire train has passed this point, speed may be resumed.

Advance Speed Limit sign shall have background of Flat Top Yellow Scotchlite. Superimposed on the yellow background shall be 7" high x 11-1/2" wide black numerals showing speed permitted over restricted territory. Numerals shall be furnished in multiples of 10 miles per hour.

Speed Limit sign shall have background of Flat Top Yellow Scotchlite.

Resume Speed sign shall have background of Flat Top Green Scotchlite.

(d) Marking of Temporary Speed Restrictions:

(1) Where it is anticipated that restriction will be of other than the most temporary nature, reflectorized slow boards will be used.

(2) Information concerning slow orders:

(i) Will be communicated to train and engine service personnel by train order or general notice.

(ii) Limits of slow orders in train order or general notice must be consistent with placement of slow boards on the ground, and order must so state.

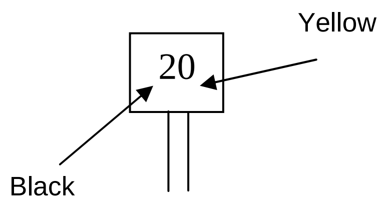
(iii) Where slow order is of short duration and is issued on train order, slow boards need not be displayed.

(3) Slow board placement:

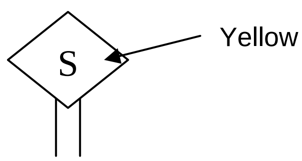
(i) Slow boards will be of reflectorized material, clean and in good repair.

(ii) They will be located to the right of and adjacent to the track protected, where they are unobstructed and can be clearly seen.

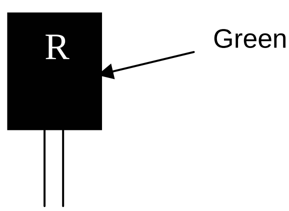
(iii) Advance Speed Limit Sign – a yellow sign with the speed to which trains are restricted displayed thereon in black numerals will be placed ahead of the point of restriction to allow a train moving at maximum authorized speed to reduce to the restricted speed at the point of restriction.



(iv) Yellow Speed Limit Sign – placed at the point at which restriction begins:



(v) Green Resume Sign – placed at the point at which restriction ends:



APPENDIX E

WEIGHTS AND MEASURES

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APPENDIX E

WEIGHTS AND MEASURES

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APPENDIX E

WEIGHTS AND MEASURES

The weights contained in these tables are for informational purposes only. Before moving and handling materials, the weights should be ascertained by contacting the appropriate manufacturer and/or supplier.

1. TIE PLATES

Tie Plate Description Conventional	Length of Plate	Width of Plate	Rail Base	Approximate Weight (lbs)
SSC(1)	10"	7-1/2"	4-7/16" to 5-1/8"	11.3
SSC	11"	7-1/2"	5-1/8" to 5-1/2"	13.1
DSC(2)	12"	7-3/4"	5-3/8"	16.2
DSC	11"	7-3/4"	5-1/2"	13.6
DSC	12"	7-3/4"	5-1/2"	16.2
DSC	13"	7-3/4"	5-1/2"	19.9
DSC	14"	7-3/4"	5-1/2"	23.3
Pandrol	15-1/8"	7-3/4"	5-1/2"	23.5
Pandrol	15-3/4"	7-3/4"	6"	24.5

Notes:
(1) Single Shoulder Canted
(2) Double Shoulder Canted

2. JOINT BARS(1)

Rail Section	Length of Bar	Approximate Weight Per Single Bar (lbs)
115/119 RE	36"	46.9
136 RE	36"	55.2

Note:
(1) If handling compromise bars, use the heavier rail weight section for the estimate of the bar weight.

3. BALLAST

	Average Weight Per Cubic Foot		Average Weight Per Cubic Yard	
Type of Ballast	**Loose (lbs)**	**Compacted (1bs)**	**Loose (1bs)**	**Compacted (lbs)**
Granite	88	98	2,375	2,650
Trap Rock	104	114	2,800	3,075

4. FASTENERS

Type	Approximate Weight (lbs)
Fast Clips (Bag of 50)	75
“e” Clips (Bag of 50)	88
Track Bolts (including Keg) (1" x 5-1/2")	210
Track Spikes (including Keg)	210
Lag Screws (Bag of 100)	110
115/119 RE Rail Anchors (Bag of 50)	125
136 RE Rail Anchors (Bag of 50)	150

5. TIES AND TIMBERS

Type	Size	Approximate Weight (lbs)
Wood Cross Tie Red or White Oak	7"x 9" x 8'-6"	246
Concrete Cross Tie	8'-6"	780
Concrete Switch Tie	9' to 16'	105 lbs/ linear foot
Wood Switch Timber (7"x 9" x Length) Total Tie Weight	9' 10' 11' 12' 13' 14' 15' 16' 21' 22'	260 289 318 347 376 405 434 462 607 636

6.0 BONDED JOINTS AND RAILS

6.a BONDED INSULATED RAIL JOINTS

Rail Size	Rail Length	Approximate Total Weight (lbs)
115 RE	19'-6"	860
115 RE	26’	1,110
115 RE	39'	1,490
136 RE	19'-6"	995
136 RE	26'	1,290
136 RE	39'	1,880

6.b RAILS

Rail Size	Calculated Weight Per Yard (lbs)	Approximate Weight (lbs)
100 NH @ 33'	100.00	1,100
107 NH @ 39'	107.00	1,391
115 RE @ 39'	114.75	1,492
136 RE @ 39'	135.80	1,766

7.0 TURNOUT PANELS

7.a TURNOUT PANELS – Conventional No. 8 on Wood Ties

(136 RE)	Panel Length	Approximate Panel Weight (tons)
Nose Panel	39'	7.5
Frog Panel	39'	9.2

7.b TURNOUT PANELS – Conventional No. 10 on Wood Ties

(136 RE)	Panel Length	Approximate Panel Weight (tons)
Nose Panel	39'	7.5
Frog Panel	39'	10.8

7.c TURNOUT PANELS – Conventional No. 15 on Wood Ties (26' Curved Switch)

(136 RE)	Panel Length	Approximate Panel Weight (tons)
Nose Panel	66'	11.5
Frog Panel	52'	15.0

7.d TURNOUT PANELS – Conventional No. 20 on Wood Ties (39' Curved Switch)

(136 RE)	Panel Length	Approximate Panel Weight (tons)
Nose Panel	70'	14.0
Frog Panel	44'	13.9

8. HOOK FLANGE GUARD RAILS

Length (136 RE)	Approximate Weight	
	(lbs)	(tons)
9'	950	0.5
13'	1,350	0.8
20'	2,100	1.1
27'	2,800	1.5

9. RAILBOUND MANGANESE FROGS[1]

Turnout No.	Length	Approximate Weight	
		(lbs)	(tons)
8	18'	4,025	2.1
10	23'	5,025	2.6
15	26'-8"	5,625	2.9
20	34'-2"	6,925	3.5

Note:
(1) Approximate weights are for maintenance frogs with extended wing rails.

10. DIAMOND TRACK CROSSINGS

3 Rail	Approximate Weight	
	(lbs)	(tons)
High Angle Crossing (Ties Not Included)	14,000	7.0
Low Angle Crossing (Ties Not Included)	18,000	9.0

11a. AREMA SWITCH RAILS (115-119 RE)

Turnout No.	Stock Rail			Split Switch Point		
	Length	Approximate Weight		Length	Approximate Weight	
		(lbs)	(tons)		(lbs)	(tons)
10	27'-0"	1071	0.55	16'-6"	655	0.35
15	38'-0"	1,507	0.75	26'-0"	1,031	0.55
20	59'-6"	2,360	1.2	39'-0"	1,547	0.78

11b. AREMA SWITCH RAILS (136 RE)

Turnout No.	Stock Rail			Split Switch Point		
	Length	Approximate Weight		Length	Approximate Weight	
		(lbs)	(tons)		(lbs)	(tons)
10	27'-0"	1,223	0.62	16'-6"	748	0.38
15	38'-0"	1,721	0.87	26'-0"	1,177	0.59
20	59'-6"	2,695	1.35	39'-0"	1,767	0.89

12. WOOD-TIE TRACK PANELS

(136 RE)	Approximate Weight (tons)
39' Panel Length(1) (w/o 3rd rail ties)	4.5
39' Panel Length(1) (with 3rd rail ties)	4.6
Note: (1) Pandrol plates 6" base and 21-1/4" tie spacing	

13. HIGHWAY GRADE CROSSINGS – CONCRETE

Std. Track Panel[1] (lbs/track foot)	Crossing Track Panel[2,4] (lbs/track foot)	Concrete Gage Crossing Module[3,4] (lbs/track foot)	Concrete Field Modules[3,4] (lbs/track foot)
490.5	629.1	458	247

Notes:

(1) Concrete ties 8'6" long, spaced at 24" o.c. with Pandrol fasteners including galvanized e-clips, and 136 RE CWR.
(2) Concrete ties 10'0" long, spaced at 24" o.c. with Pandrol fasteners including galvanized e-clips and 136 RE CWR.
(3) Concrete crossing modules (available 8' or 12' lengths) for gage of track or field side.
(4) Total approximate weight per track foot is the crossing panel weight, the gage crossing module weight and two (2) times the field module weight.

14. HIGHWAY GRADE CROSSINGS – RUBBER

Shipping Weight Average per Skid (lbs)	Full Depth Heavy Duty Rubber Gage Crossing Pad[1,3] (each)	Full Depth Heavy Duty Rubber Field Crossing Pad[2,3] (each)
3,111	595	224

Notes:

(1) Rubber gage pad 3' length x 58-1/2" width x 8-1/4" depth for 136 RE rail.
(2) Rubber field pad 3' length x 22" width x 8-1/4" depth for 136 RE rail.
(3) Total approximate weight per track foot is the crossing panel weight, the gage crossing module weight and two (2) times the field module weight.

15. DECIMALS OF AN INCH

Fraction (inches)	Decimal (inches)
1/32	0.03125
1/16	0.06250
3/32	0.09375
1/8	0.12500
5/32	0.15625
3/16	0.18750
7/32	0.21875
1/4	0.25000
9/32	0.28125
5/16	0.31250
11/32	0.34375
3/8	0.37500
13/32	0.40625
7/16	0.43750
15/32	0.46875
1/2	0.50000
17/32	0.53125
9/16	0.56250
19/31	0.59375
5/8	0.62500
21/32	0.65625
11/16	0.68750
23/32	0.71875
3/4	0.75000
25/32	0.78125
13/16	0.81250
27/32	0.84375
7/8	0.87500
29/32	0.90625
15/16	0.93750
31/32	0.96875
1	1.00000

APPENDIX F

FORMS

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APPENDIX F

FORMS

These forms are typical forms used in the inspection of maintenance of track and special track work by the MassDOT Rail and Transit Division.

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RAIL DEFECT INSPECTION REPORT

massDOT
Massachusetts Department of Transportation
Rail & Transit Division

Operating Railroad Name: ______________________________ Date of Inspection: ____________

Detector Car Operator Name: ______________________________

Route Tested: ______________________________ Track __________ MP __________ to MP __________

Inspection Company: ______________________________ Track __________ MP __________ to MP __________

Detector Car #: ______________________________ Track __________ MP __________ to MP __________

Detector Car Defect Number	Defect Type	Defect Size	Track Number	Mile Post	Immediate Corrective Action	Date	Final Corrective Action	Date

To be signed and submitted after all final active correction is complete:

*Operating Railroad Supervisor's Name: ______________________________ Date: ______________

*Operating Railroad Supervisor's Signature: ______________________________

*NOTE: Operating Railroad Supervisor is the Railroad Supervisor riding the detector car.

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SPECIAL TRACK INSPECTION REPORT

massDOT
Massachusetts Department of Transportation
Rail & Transit Division

Name of Operating Railroad:		
Date Inspection Made:	Line Segment:	
Reason for Inspection:	Weather:	Temperature:

Location		Conditions Noted / Repairs Made
Track Name/No.	M.P. – M.P.	

Deficiencies/Defects Found	Corrective Action Taken

Operating Railroad Inspector's Name: (Print)
Operating Railroad Inspector's Signature:

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RAIL FAILURE REPORT

Name of Operating Railroad:			
Date Discovered:		**Date Repaired:**	
Line Segment:	**MP:**	**Track:**	**Rail:** N / S / E / W
Defect Location:			
Rail: Tangent **Curve:** High Rail Low Rail Degree of curve:			
Notes:			
Special Work Type:	**MP:**	**Turnout Name:**	
Notes:			
Detector Car Defect: No Yes		**Defect No:**	
Type of Defect:		**Size of Defect:**	
Service Failure Defect: No Yes	**Type:**		**Found by:**
Type of Rail: Jointed CWR			
Rail Weight:	**Rail Section:**		**Manufacturer:**
Year Rolled:	**Month Rolled:**		
Type of Weld: Field Plant		**Joint Bars to Weld:** No Yes	
Rail Information:			
Temporary Speed Restriction (TSR): No Yes ________________ MPH			
Defective Glued Plugged Rail: No Yes Length _________			
CWR Plug Rail Installed: No Yes Length _________			**Plug Rail Number:** _____ - _____ - _____
Boxed Anchored 200' from Joints: No Yes		**Form "TD" Required:** No Yes	
Rail Temperature when Anchoring:			
To be signed and submitted after all final active correction is complete:			
Operating Railroad Supervisor's Name: (Print)			
Operating Railroad Supervisor's Signature:			**Date:**

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CWR RAIL EXPANSION/HEAT RECORD REPORT

massDOT Massachusetts Department of Transportation Rail & Transit Division

Operating Railroad/Contractor:		Weather:
Line Segment:	MP:	Track:

Date	Track Name/No.	Rail (N,S,E,W)	String Number	Start MP	End MP	Rail Temp. (°F)(1)	Req'd Temp. Change (°F)(2)	String Length (Feet)	Required Expansion (Inches)(3)	Installation Temp. Achieved (°F)	String Vibrated (Y/N)	Actual Expansion Recorded (Inches) Obtained at 1/4 Points(4)			
												1/4	1/2	3/4	Full

Notes:
(1) Temperature to be measured with approved rail thermometer.
(2) Required temperature change in °F is preferred rail neutral temperature of 110°F (RNT) minus the actual rail temperature at the time of expansion.
(3) See formula and table on reverse side of form.
(4) After string is anchored and/or clipped.

Operating Railroad Foreman's Signature: ______________________________ **Date:** __________

Operating Railroad Foreman's Name (Print): ______________________________

<u>Formula for Coefficient of Linear Expansion of Rail:</u>

$A = 0.000078 \times (T_D - T_E) \times L$

A	=	Adjustment or Required Expansion amount of rail string (in inches)
T_D	=	Desired Rail Neutral Temperature (RNT) should be 110°F if possible as conditions permit
T_E	=	Existing or Actual Rail Temperature (°F) prior to heating or expansion measured with an approved rail thermometer
L	=	Length of string to be adjusted (in feet)

Calculations:

Change in Rail Length Due to Change in Rail Temperature

A = Change in Rail Length in Inches = 0.000078ΔT x L
L = Length of Rail to be Expanded in Feet
ΔT = Change in Temperature in Degrees Fahrenheit: Desired RNT minus Actual Rail Temperature

Length of Rail (ft)	Change in Temperature in Degrees Fahrenheit															
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	Change in Rail Length in Inches															
100	1/8	1/8	1/8	1/4	1/4	1/4	3/8	3/8	3/8	1/2	1/2	1/2	5/8	5/8	5/8	5/8
200	1/8	1/4	1/4	3/8	1/2	1/2	5/8	5/8	3/4	7/8	7/8	1	1-1/8	1-1/8	1-1/4	1-1/4
300	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-3/4	1-7/8	1-7/8
400	1/4	3/8	1/2	5/8	7/8	1	1-1/8	1-1/4	1-1/2	1-5/8	1-3/4	1-7/8	2-1/8	2-1/4	2-3/8	2-1/2
500	1/4	1/2	5/8	7/8	1	1-1/4	1-3/8	1-5/8	1-7/8	2	2-1/4	2-3/8	2-5/8	2-3/4	3	3-1/8
600	1/4	1/2	3/4	1	1-1/4	1-1/2	1-3/4	1-7/8	2-1/8	2-3/8	2-5/8	2-7/8	3-1/8	3-3/8	3-5/8	3-3/4
700	3/8	5/8	7/8	1-1/8	1-3/8	1-3/4	2	2-1/4	2-1/2	2-3/4	3-1/8	3-3/8	3-5/8	3-7/8	4-1/8	4-3/8
800	3/8	5/8	1	1-1/4	1-5/8	1-7/8	2-1/4	2-1/2	2-7/8	3-1/8	3-1/2	3-3/4	4-1/8	4-3/8	4-3/4	5
900	3/8	3/4	1-1/8	1-1/2	1-7/8	2-1/8	2-1/2	2-7/8	3-1/4	3-5/8	3-7/8	4-1/4	4-5/8	5	5-3/8	5-5/8
1000	1/2	7/8	1-1/4	1-5/8	2	2-3/8	2-3/4	3-1/8	3-5/8	4	4-3/8	4-3/4	5-1/8	5-1/2	5-7/8	6-1/4
1100	1/2	7/8	1-3/8	1-3/4	2-1/4	2-5/8	3-1/8	3-1/2	3-7/8	4-3/8	4-3/4	5-1/4	5-5/8	6-1/8	6-1/2	6-7/8
1200	1/2	1	1-1/2	1-7/8	2-3/8	2-7/8	3-3/8	3-3/4	4-1/4	4-3/4	5-1/4	5-5/8	6-1/8	6-5/8	7-1/8	7-1/2
1300	5/8	1-1/8	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8	4-5/8	5-1/8	5-5/8	6-1/8	6-5/8	7-1/8	7-5/8	8-1/8
1400	5/8	1-1/8	1-3/4	2-1/4	2-3/4	3-3/8	3-7/8	4-3/8	5	5-1/2	6-1/8	6-5/8	7-1/8	7-3/4	8-1/4	8-3/4
1440	5/8	1-1/8	1-3/4	2-1/4	2-7/8	3-3/8	4	4-1/2	5-1/8	5-5/8	6-1/4	6-3/4	7-3/8	7-7/8	8-1/2	9
1600	5/8	1-1/4	1-7/8	2-1/2	3-1/8	3-3/4	4-3/8	5	5-5/8	6-1/4	6-7/8	7-1/2	8-1/8	8-3/4	9-3/8	10

DOCUMENT B00420

PROPOSAL

LENOX AND LEE

For: **Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line**

COMMONWEALTH OF MASSACHUSETTS

LOCATION: LENOX AND LEE

The work referred to herein is in the Towns or Cities of Lenox and Lee in Berkshire County, in the Commonwealth of Massachusetts, and is shown by the locus map (Document 00331) in the Proposal Pamphlet.

The contract prices shall include the furnishing of all materials (except as otherwise herein specified), the performing of all the labor requisite or proper, the providing of all necessary machinery, tools, apparatus and other means of construction, the doing of all the abovementioned work in the manner set forth, described and shown in the specifications and on the drawings for the work, and in the form of contract, and the completion thereof within **560 CALENDAR DAYS** upon receipt of a Notice to Proceed, except that if the completion date falls between December 1 and March 15 then the same number of days beyond December 1st will be extended after March 15th.

The Work of this project is described by the following Items and quantities.

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Project #: 613045 Contract #:120593				
Location: Lenox and Lee				
Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line				
ITEM #	QUANTITY	ITEM WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT PRICE	AMOUNT
100	1	SCHEDULE OF OPERATIONS - FIXED PRICE AT Forty-Two Thousand Dollars LUMP SUM	$ 42,000.00	$ 42,000.00
115.1	1	DEMOLITION OF BRIDGE NO. 77.04 AT ______________________________ LUMP SUM		
115.2	1	DEMOLITION OF BRIDGE NO. 79.81 AT ______________________________ LUMP SUM		
151.2	176	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES AT ______________________________ PER CUBIC YARD		
153	53	RAPID SET FLOWABLE FILL AT ______________________________ PER CUBIC YARD		
156	95	CRUSHED STONE AT ______________________________ PER TON		
180.1	1	HEALTH AND SAFETY PLAN AT ______________________________ LUMP SUM		
180.2	100	IMPLEMENTATION OF HEALTH AND SAFETY PLAN AT ______________________________ PER HOUR		
458.6.1	645	FURNISH BALLAST AT ______________________________ PER TON		
492.2	8	FURNISH TRACK SPIKES (100# Kegs) AT ______________________________ PER KEG		
492.8	3,575	SURFACE AND ALIGN BALLASTED TRACK AT ______________________________ PER TRACK FOOT		
492.11.1	264	TRACK RECONSTRUCTION AT ______________________________ PER TRACK FOOT		
492.12	60	TRACK UNDERDRAIN AT ______________________________ PER LINEAR FOOT		
493.1	1	MISCELLANEOUS WORK AS DIRECTED BY THE ENGINEER AT Five Hundred Thousand Dollars ALLOWANCE	$ 500,000.00	$ 500,000.00

Project #: 613045 Contract #:120593				
Location: Lenox and Lee				
Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line				
ITEM #	QUANTITY	ITEM WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT PRICE	AMOUNT
698.4	295	GEOTEXTILE FABRIC FOR PERMANENT EROSION CONTROL AT ____________________ PER SQUARE YARD		
748	1	MOBILIZATION AT____________________ LUMP SUM		
755.35	1	INLAND WETLAND REPLICATION AREA AT ____________________ LUMP SUM		
767.121	2469	SEDIMENT CONTROL BARRIER AT ____________________ PER LINEAR FOOT		
850.41	1	RAILROAD SERVICES AT Three Hundred Thousand Dollars ALLOWANCE	$ 300,000.00	$ 300,000.00
850.42	1	WORK TRAINS AT Thirty Thousand Dollars ALLOWANCE	$ 30,000.00	$ 30,000.00
942.144*	1370	STEEL PILE HP 14 X117 AT ____________________ PER LINEAR FOOT		
945.10**	1550	DRILLED MICROPILE AT ____________________ PER LINEAR FOOT		
948.41*	8	DYNAMIC LOAD TEST BY CONTRACTOR AT ____________________ EACH		
948.5*	20	PILE SHOES AT ____________________ EACH		
948.60**	2	MICROPILE TEST AT ____________________ EACH		
952.0	113000	STEEL SHEET PILE AT____________________ PER SQUARE POUND		
983.1	335	RIPRAP AT ____________________ PER TON		

Project #: 613045 Contract #:120593				
Location: Lenox and Lee				
Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line				
ITEM #	QUANTITY	ITEM WITH UNIT BID PRICE WRITTEN IN WORDS	UNIT PRICE	AMOUNT
991.1	1	CONTROL OF WATER - BRIDGE NO. 77.04 AT ______________________________ LUMP SUM		
991.2	1	CONTROL OF WATER - BRIDGE NO. 79.81 AT ______________________________ LUMP SUM		
995.01	1	BRIDGE STRUCTURE, BRIDGE NO. 77.04 AT ______________________________ LUMP SUM		
995.02	1	BRIDGE STRUCTURE, BRIDGE NO. 79.81 AT ______________________________ LUMP SUM		

*Only fill for using H-pile option

**Only fill for using micropile option

TOTAL CONTRACT PROPOSED PRICE AT ______________________________

$ ______________________________

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Project Location: **LENOX AND LEE**

This bid includes the following Addenda numbered: ______, ______, ______, ______, ______, ______, ______,

______, ______, ______, ______, ______, ______, ______, ______, ______, ______, ______, ______, ______.

The foregoing prices shall include the furnishing of all materials (except as otherwise herein specified), the performing of all the labor requisite or proper, the providing of all necessary machinery, tools, apparatus and other means of construction, the doing of all the above mentioned work in the manner set forth, described and shown in the specifications and on the drawings for the work, and in the form of contract, and the completion thereof within **560 CALENDAR DAYS** upon receipt of a Notice to Proceed, except that if the completion date falls between December 1 and March 15 then the same number of days beyond December 1st will be extended after March 15th.

In accordance with M.G.L. c. 30, § 39S, the undersigned hereby certifies, under the penalties of perjury, (1) that he is able to furnish labor that can work in harmony with all other elements of labor employed or to be employed in the work; (2) that all employees to be employed at the worksite will have successfully completed a course in construction safety and health approved by the United States Occupational Safety and Health Administration that is at least 10 hours in duration at the time the employee begins work and who shall furnish documentation of successful completion of said course with the first certified payroll report for each employee; and (3) that all employees to be employed in the work subject to this bid have successfully completed a course in construction safety and health approved by the United States Occupational Safety and Health Administration that is at least 10 hours in duration.

If this proposal shall be accepted and the undersigned shall fail to contract as aforesaid and to give a performance and payment bond in the sum to be determined as aforesaid with surety satisfactory to the Party of the First Part within fourteen (14) calendar days from the date of the mailing of notice from the Party of the First Part to him/her, according to the address herewith given, that the contract is ready for signature, the Party of the First Part may, at his/her option, determine that the Bidder has abandoned the contract, and thereupon this proposal, and the acceptance thereof shall be null and void, and the proposal guaranty submitted covering this proposal shall become the property of the PARTY OF THE FIRST PART otherwise the said proposal guaranty shall be returned to the undersigned.

Full name and address of individual, firm, partnership or corporation submitting this bid:

____

____

____

____

Address for payments, if different:

____

____

____

Signed by: ______________________________ Title: ______________________________

Vendor code : VC____

NOTICE: Bid shall be signed in black ink by person having proper legal authority, and the person's title should be given, such as "owner" in the case of an individual, "partner" in the case of a general partnership, "president",

"treasurer" or "secretary" in the case of a corporation.

__________________________________ ____
Owner or Partner Address

If bidder is a corporation, give the State in which incorporated and the names and business addresses of the following officers:

__________________________________ ____
President Address

__________________________________ ____
Treasurer Address

__________________________________ ____
Secretary Address

State here if bid is submitted by joint ventures: ____

____ and if any of the joint venturers is a corporation, a copy of the vote of the corporation authorizing the joint venture should be attached hereto.

The proposed surety on the bond to be given is:

Name ____

Home Office Address ____

Massachusetts Address ____
(if different)

NOTE: Zip Code shall be included with all addresses.

*** END OF DOCUMENT ***

DOCUMENT B00438

AFFIDAVIT OF NON-COLLUSION

COMMONWEALTH OF MASSACHUSETTS
MassDOT Rail and Transit Division
10 PARK PLAZA, BOSTON, MASSACHUSETTS

Project No: 613045-120593

Location: LENOX AND LEE

Project Description: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line

The undersigned certifies under penalties of perjury that this bid is in all respects bona fide, fair and made without collusion or fraud with any other person. As used in this paragraph the word "person" shall mean any natural person, joint venture, partnership, corporation or other business or legal entity. The undersigned further certifies that said bidder has not, either directly or indirectly, entered into any agreement or otherwise taken any action in restraint of free competitive bidding in connection with this proposal(s).

The undersigned, under the pains and penalties of perjury, says that he/she is the sole owner, partner, president, treasurer, or other duly authorized agent or official of

____
(Name of Bidder as appearing in submitted proposal)

____
(Address of Bidder)

____
(City, State, Zip Code)

____
(Telephone Number of Bidder)

____ Date ____________________
Signature and title of person making affidavit

NOTE: Failure to complete this Affidavit will result in this bid being declared non-responsive and not eligible for award consideration.

DOCUMENT B00842

SCHEDULE OF PARTICIPATION
BY MINORITY OR WOMEN BUSINESS ENTERPRISES (M/WBE)

MASSDOT PROJECT NUMBER: 613045

PROJECT LOCATION: LENOX AND LEE, MA

DATE OF BID OPENING: ______

NAME OF PRIME BIDDER: ______

Name Address and Phone Number of M/WBE	Name of Activity	(a) M/WBE Contractor Activity Amount	(b) M/WBE Other Business Amount	(c) Total amount eligible for credit under rules in Section VIII of the Special Provisions
Total Bid Amount	TOTALS:	$		$
$	M/WBE Percentage of Total bid:	%		%

Column (a) must be at least one-half of the M/WBE percentage goal.

SIGNATURE: ______ Date: ______ Tel No: ______

NAME AND TITLE (PRINT):______

BIDDERS ARE CAUTIONED TO REVIEW DOCUMENT 00718 -- SPECIAL PROVISION FOR PARTICIPATION BY MINORITY OR WOMEN BUSINESS ENTERPRISES AND SERVICE DISABLED VETERAN OWNED BUSINESS ENTERPRISES.

*** END OF DOCUMENT ***

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DOCUMENT B00843

MINORITY OR WOMEN'S BUSINESS ENTERPRISE PARTICIPATION LETTER OF INTENT
PAGE 1 OF 2

MASSDOT PROJECT NUMBER: 613045

PROJECT LOCATION: LENOX AND LEE, MA

DATE OF BID OPENING: ____________________

FROM ____________________
(Minority or Women's Business Enterprise Company)

TO: ____________________
(Name of Prime Contractor)

1. My company is currently certified as an MBE or WBE by the Massachusetts Supplier Diversity Office, formerly known as the State Office of Minority and Women Business Assistance (SOMWBA). There have been no changes affecting the ownership, control or independence of my company since my last certification review.

2. If any such change occurs prior to my company's completion of this proposed work, I will give written notification to your firm and to the Massachusetts Department of Transportation (MassDOT).

3. (For contractor activity only.) My firm will provide to you, upon request, for the purpose of obtaining subcontractor approval from MassDOT; (1) a resume stating the qualifications and experience of the superintendent or foreperson who will supervise on site-work; (2) a list of equipment owned or leased by my firm for use on the project; (3) a list of all projects (public or private) which my firm is currently performing, is committed to perform, or intends to make a commitment to perform. I shall include, for each project, the names and telephone number of a contact person for the contracting organization, the dollar value of the work, a description of the work, and my firm's work schedule for the Project.

4. If you are awarded the Contract, my company intends to enter into an agreement with your firm to perform the items of work or other activity described on the following sheet for the prices indicated.

5. My firm has the ability to manage, supervise and perform the activity described on the following page.

____________________ ____________________
M/WBE Authorized Signature Date

MINORITY OR WOMEN'S BUSINESS ENTERPRISE PARTICIPATION LETTER OF INTENT
PAGE 2 OF 2

MASSDOT PROJECT NUMBER: 613045

PROJECT LOCATION: LENOX AND LEE, MA

DATE OF BID OPENING: ______

NAME OF PRIME BIDDER: ______

Item number if applicable	Description of Activity with notations such as Labor Only, Material Only, or Complete	Quantity	Unit Price	Amount
		TOTAL AMOUNT:		

M/WBE COMPANY NAME: ______

M/WBE AUTHORIZED SIGNATURE: ______

NAME AND TITLE (PRINT): ______

TELEPHONE NUMBER: ______ FAX NUMBER: ______

*** END OF DOCUMENT ***

DOCUMENT B00846

M/WBE OR SDVOBE JOINT CHECK ARRANGEMENT APPROVAL FORM

(to be submitted by Prime Contractor)

Contract No: 120593 **Project No.** 613045

Location: LENOX AND LEE, MA

Bid Opening Date: ______________________ ______________________

Project Description: Replacement of Railroad Bridges 77.04 and 79.81 on MassDOT Berkshire Line

We have received the attached request for the use of a joint check arrangement from ________________ ________________________ , a M/WBE or SDVOBE on the above- referenced Contract and __________________________ ________________, a Material Supplier/Vendor for the subject Contract. The M/WBE or SDVOBE has complied with the requirements of Special Provision Document 00718. In particular, the M/WBE or SDVOBE has:

- a written agreement with the material supplier/vendor;
- applied for credit with the subject material supplier and has supplied the vendor's response;
- shown that it will place all orders to the subject material supplier/vendor;
- made and retains all decision-making responsibilities concerning the materials; and
- provided a Joint Check Agreement that is acceptable to MassDOT;

As the Contractor for the Project, we agree to issue joint checks (made payable to the Material Supplier/Vendor and the M/WBE or SDVOBE) for payment of sums due pursuant to invoices from the Supplier/Vendor and M/WBE or SDVOBE.

Contractor:

Company Name	Signature Duly Authorized
	Printed Name
Date	Title

SubContractor:

Company Name	Signature – Duly Authorized
	Printed Name
Date	Title

*** END OF DOCUMENT ***

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DOCUMENT B00847

JOINT VENTURE AFFIDAVIT
(All Firms)

- All Information Requested By This Schedule Must Be Answered. Additional Sheets May Be Attached.
- If, there is any change in the information submitted, the Joint Venture parties must inform MassDOT Pre-Qualifications Office (and, if one of the companies is a M/WBE or SDVOBE, the Director of Contract Compliance, Office of Civil Rights) *prior* to such change, in writing, either directly or through the Prime Contractor if the Joint Venture is a subcontractor.
- If the Joint Venture Entity will be the bidder on a prime Contract, it must bid and submit all required documents (insurance, worker's compensation, bonds, etc.) in the name of the Joint Venture Entity.

I. Name of Joint Venture: ______________________________

Type of Entity if applicable (Corp., LLC):____________________Filing State ________________

Address of joint venture: ______________________________

____

Phone No(s) for JV Entity: ________________________E-mail:__________________________

Contact Person(s)______________________________

Tax ID/EIN of Joint Venture: ______________________Vendor Code:_____________________

II. Identify each firm or party to the Joint Venture:

Name of Firm: ______________________________

Address: ______________________________

Phone : __________________________________E-mail:__________________________________

Contact person(s) ______________________________

Name of Firm: ______________________________

Address: ______________________________

Phone: __________________________________E-mail:__________________________________

Contact Person(s)______________________________

III. Describe the role(s) of the each party to the Joint Venture:

____

____

IV. Attach a copy of the Joint Venture Agreement. The proposed Joint Venture Agreement should include specific details including, but not limited to: (1) the contributions of capital and equipment; (2) work items to be performed by each company's forces, (3) work items to be performed under the supervision of any M/WBE or SDVOBE Venturer; (4) the commitment of management, supervisory and operative personnel employed by the M/WBE or SDVOBE to be dedicated to the performance of the Project; and (5) warranty, guaranty, and indemnification clauses.

V. Attach any applicable Corporate or LLC Votes, Authorizations, etc.

VI. Ownership of the Joint Venture:

A. What is the percentage(s) of each company's ownership in the Joint Venture?

ownership percentage(s): ____

ownership percentage(s): ____

B. Specify percentages for each of the following (provide narrative descriptions and other detail as applicable):

1. Sharing of profit and loss: ____

2. Capital contributions:

(a) Dollar amounts of initial contribution: ______________________________

(b) Dollar amounts of anticipated on-going contributions:______________________

(c) Contributions of equipment (specify types, quality and quantities of equipment to be provided by each firm): ____

____

4. Other applicable ownership interests, including ownership options or other agreements, which restrict or limit ownership and/or control:

____

____

5. Provide copies of all other written agreements between firms concerning bidding and operation of this Project or projects or contracts.

6. Identify all current contracts and contracts completed during the past two (2) years by either of the Joint Venture partners to this Joint Venture:

____

____

VII. Control of and Participation in the Joint Venture.

Identify by name and firm those individuals who are, or will be, responsible for and have the authority to engage in the following management functions and policy decisions. (Indicate any limitations to their authority such as dollar limits and co-signatory requirements.):

A. Joint Venture check signing:

____

____

B. Authority to enter Contracts on behalf of the Joint Venture:

____

____

C. Signing, co-signing and/or collateralizing loans:

____

____

D. Acquisition of lines of credit:

____

____

E. Acquisition and indemnification of payment and performance bonds:

____

____

F. Negotiating and signing labor agreements:

____

____

G. Management of contract performance. *(Identify by name and firm only)*:

1. Supervision of field operations: ______________________________
2. Major purchases: ______________________________
3. Estimating: ______________________________
4. Engineering: ______________________________

VIII. Financial Controls of Joint Venture:

A. Which firm and/or individual will be responsible for keeping the books of account?

____

____

B. Identify the "Managing Partner," if any, and describe the means and measure of their compensation:

____

____

C. What authority does each firm have to commit or obligate the other to insurance and bonding companies, financing institutions, suppliers, subcontractors, and/or other parties participating in the performance of this Contract or the work of this Project?

____

IX. Personnel of Joint Venture: State the approximate number of personnel (by trade) needed to perform the Joint Venture's work under this Contract. Indicate whether they will be employees of the majority firm, M/WBE or SDVOBE firm, or the Joint Venture.

	Firm 1 (number)	Firm 2 (number)	Joint Venture (number)
Trade			
Professional			
Administrative/Clerical			
Unskilled Labor			

Will any personnel proposed for this Project be employees of the Joint Venture?: ______________

If so, who: ____

A. Are any proposed Joint Venture employees currently employed by either firm?

Employed by Firm 1: _____________Employed by firm 2 ______________________________

B. Identify by name and firm the individual who will be responsible for Joint Venture hiring: ____

____

X. Additional Information. Please state any material facts and additional information pertinent to the control and structure of this Joint Venture.

____

____

XI. AFFIDAVIT OF JOINT VENTURE PARTIES. The undersigned affirm that the foregoing statements and attached documents are correct and include all material information necessary to identify and explain the terms and operations of our Joint Venture and the intended participation of each firm in the undertaking. Further, the undersigned covenant and agree to provide to MassDOT current, complete and accurate information regarding actual Joint Venture work, payments, and any proposed changes to any provisions of the Joint Venture, or the nature, character of each party to the Joint Venture. We understand that any material misrepresentation will be grounds for terminating any Contract awarded and for initiating action under Federal or State laws concerning false statements.

Firm 1	Firm 2
Signature Duly Authorized	Signature Duly Authorized
Printed Name and Title	Printed Name and Title
Date	Date

*** END OF DOCUMENT ***

APPENDIX A

GEOTECHNICAL REPORTS

BR. 77.04 GEOTECHNICAL REPORT
(BR. 77.16 = BR. 77.04 IN REPORT)

Consulting
Engineers and
Scientists

Revised March 27, 2020
November 11, 2019
Project 1703257

VIA EMAIL: June.Wu@hdrinc.com

Ms. June Wu, P.E.
HDR Engineering, Inc.
99 High Street, Suite 2300
Boston, Massachusetts 02110

Dear Ms. Wu:

Re: Geotechnical Recommendations for Bridge Replacement
Berkshire Line Bridge - Mile Post 77.16
Lee, Massachusetts

This letter report presents the results of our subsurface explorations and our geotechnical recommendations for the replacement of the Massachusetts Department of Transportation (MassDOT) Berkshire Line Bridge at Mile Post 77.16 in Lee, Massachusetts.

We performed the following scope of work:

- Performed one boring at the north bridge abutment.
- Performed one boring at the south bridge abutment.
- Performed one boring at the midspan of the bridge.
- Submitted soil samples collected from the river bottom soil to a laboratory for grain size analyses to support a scour analysis, which was performed by others.
- Evaluated the subsurface conditions and developed basic soil properties and recommendations for replacement of the existing bridge.
- Prepared this letter report presenting the results of our subsurface explorations, our analyses, and our recommendations.

We performed this work under the Subconsultant Agreement between HDR Engineering, Inc. and GEI Consultants, Inc., dated August 1, 2017 and Amendment #2 to the Subconsultant Agreement, dated September 10, 2018. Our scope of work is based on our proposal dated July 10, 2018.

Elevations in this report are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88). Boring depths are referenced to the top of the existing train rail near each boring location, at approximately El. 919.

Site and Project Description

The MassDOT Berkshire line Railroad Bridge at Mile Post 77.16 crosses Codding Brook about 200 feet west of Bradley Street in Lee, Massachusetts (Fig. 1). The existing bridge is a five-span timber structure, about 37 feet long, supported by four timber bents and a timber dump wall at each abutment as shown in Fig. 2. Stone retaining walls are located directly behind bents 2 and 3.

We understand that the existing five-span bridge is experiencing distress and that the bridge substructure will be replaced to accommodate a wider bridge deck for a new two-span bridge. The existing timber bents, piles, dump walls, and stone retaining walls will be removed and the proposed substructure for the new bridge will consist of a precast concrete pier cap at midspan and precast concrete abutments, all supported on pile foundations.

Subsurface Explorations

Borings

Aquifer Drilling and Testing, Inc. of Mineola, New York, drilled three borings (B501 through B503) from October 10, 2018 to October 17, 2018. The boring locations are shown in Fig. 2. The boring logs are provided in Appendix A. A GEI engineer was on site full time to coordinate the work and log the borings.

The borings were drilled using a CME hi-rail mounted truck drill rig and advanced using wash-rotary techniques with flush jointed casing. The borings were performed along the centerline of the tracks about 5 feet behind the north abutment (B501), 3 feet behind the south abutment (B502), and at midspan (B503). Standard Penetration Tests (SPTs) were performed using an automatic hammer, and bedrock was cored in B501 and B502 using an NX type core barrel.

B501 was advanced to a depth of 65 feet below the top of rail. Bedrock was encountered at a depth of 60 feet and was cored for 5 feet. B502 was advanced to a depth of 70 feet below the top of rail. Bedrock was encountered at a depth of 60 feet and was cored for 10 feet. B503 was advanced to a depth of 37 feet below the top of rail and terminated in glacial till. The streambed was approximately 10.4 feet below the top of rail at midspan of the bridge. Bedrock was not encountered in B503.

Laboratory Testing

We submitted four split spoon soil samples from B503 to GeoTesting Express of Acton, Massachusetts to evaluate soil gradation to support a scour analysis performed by others. Results of the grain size analyses are provided in Appendix B.

Subsurface Conditions

The soil layers encountered in the borings are described below, in order of increasing depth. A simplified subsurface profile is shown in Fig. 3. Subsurface conditions are known only at sample locations, and may differ significantly from those shown in Fig. 3 and described below. These variations may not become evident until construction.

- <u>Fill</u> - An approximate 10-foot-thick layer of fill consisting of sand and gravel was encountered at the ground surface in B501 and B502 behind the abutments. The SPT-N values ranged from 7 to 30 blows per foot (bpf) indicating a loose to medium dense soil.

- Sand and Gravel – An approximate 10-foot-thick layer of sand and gravel was encountered at the top of the stream bed in B503. The SPT N-values ranged from 28 to over 100 bpf indicating a medium dense to very dense soil. The high SPT N-values were likely influenced by the presence of gravel and timber.
- Organics – A thin (approximately 2-foot-thick) layer of organic soil was encountered below the fill in B501. This soil layer consisted of gray silty sand with approximately 40% nonplastic fines. The SPT N-value was 2 bpf indicating a very loose soil.
- Silty Sand – Silty sand was encountered beneath the organics in B501 and beneath the sand and gravel in B503. The silty sand consisted of mostly fine to coarse sand with gravel in some samples and varying amounts of nonplastic fines. The thickness of the silty sand layer varied between approximately 1 and 5 feet. The SPT N-values ranged from 26 to 51 bpf indicating a medium dense to very dense soil.
- Glacial Till – Glacial till was encountered in all of the borings at depths of 9 to 25 feet below top of rail, corresponding to El. 910 to El. 894. The glacial till consisted of mostly silty gravel with sand with some interbedded layers of silty sand. SPT N-values ranged from 15 to 132 bpf indicating a medium dense to very dense soil.
- Weathered Bedrock – A 5-foot-thick layer of very dense, gray, tan, and white weathered rock was encountered below the glacial till in B501 and B502. The SPT N-values were 50/2” and 100/4”.
- Bedrock – Medium hard, moderately fractured to highly fractured, dolomitic marble bedrock was encountered approximately 60 feet below top of rail (approximately El. 859) in B501 and B502.

Water Levels

The river level during the subsurface exploration was measured at approximately El. 910.9, which was 8.1 feet below the top of the rail. Groundwater was measured in B501 at approximately El. 910, which was 8.8 feet below the top of the rail. The river and groundwater levels may vary significantly at other times. Groundwater levels are expected to vary with river levels.

The 100-year flood elevations for the existing and proposed conditions at the bridge are El. 916.75 and El. 914.38, respectively (HDR, 2019).

Soil Properties

Recommended soil properties for analysis and design are presented below. We estimated these values based on published correlations to SPT N-values and visual soil and rock descriptions.

Stratum	Friction Angle, Φ (deg)	Unit Weight, lb/ft^3
Fill	30	125
Sand and Gravel	30	125
Silty Sand	32	130
Glacial Till	38	135

Seismic Design Information

We recommend the following seismic design criteria based on the AREMA 2016 Manual for Railway Engineering (AREMA, 2016) and the 2014 United States Geological Society Hazard Mapping Data. Based on the boring data, we recommend using Site Class C (AREMA Chapter 9, Part 1, Section 1.4.4.1.1).

Base Acceleration Coefficients (AREMA Section 1.3.2.3)	
475-Year Return Period	**2,475-Year Return Period**
PGA_{475}=0.033	PGA_{2475}=0.084
$S_{S,475}$=0.069	$S_{S,2475}$=0.158
$S_{1,475}$=0.020	$S_{1,2475}$=0.047

Site Factors (AREMA Section 1.4.4.1.2)	
475-Year Return Period	**2,475-Year Return Period**
$F_{PGA-475}$=1.2	$F_{PGA-2475}$=1.2
F_{a-475}=1.2	F_{a-2475}=1.2
F_{v-475}=1.7	F_{v-2475}=1.7

Based on our evaluation of the borings and our review of the soil samples collected in the borings, it is our opinion that the soils are not susceptible to earthquake-induced liquefaction.

Recommendations

Abutment and Pier Foundation Recommendations

We recommend supporting the new pier and abutments on driven piles. The piles should be driven to refusal in the glacial till or on bedrock. We understand that the construction will be sequenced to minimize disruption to weekday service and will take place during non-train operation hours or foul time. The demolition of the existing bridge and foundations, construction of precast concrete bridge abutments, precast concrete pier cap, and the superstructure will also be sequenced to take place on a weekend shutdown to avoid interruption of train operations.

We understand the maximum axial loads at the abutments and pier are approximately 400 and 540 kips, respectively. The maximum lateral loads at the abutments and pier are approximately 156 and 0 kips, respectively. Based on the loads above and our lateral analyses, we recommend evaluating an HP14x117 for the driven piles.

Due to the potential for pile damage during driving from cobbles and boulders in the sand and gravel and glacial till layers, we recommend specifying HP14x117 piles with high strength cast steel tip reinforcement such as Associated Pile & Fitting's Hard-Bite Points.

To verify axial capacity and the pile driving criteria, we recommend that the piles be monitored during driving using the Pile Driving Analyzer (PDA) with signal matching. We recommend specifying an ultimate vertical capacity of 2.25 times the maximum working load (using allowable stress design load combinations) for pile resistances verified using PDA testing. We recommend PDA testing be performed on at least one abutment pile on each side, one battered pier pile, and one vertical pier pile for a total of at least 4 piles.

The piles will also be subjected to lateral loads due to lateral soil pressure on the abutments, lateral soil pressure from the railroad surcharge, and longitudinal bridge forces. We understand the structure will be detailed to allow either the north or south abutments to be engaged based on the direction of loading. Our lateral load analyses for a typical abutment and the pier are provided in Appendix C. To provide adequate lateral load resistance, we recommend advancing the piles a minimum of 16 feet into glacial till (highest allowable tip elevations of approximately El. 888 at the north abutment, El. 894 at the south abutment, and El. 878 at the pier). However, we expect the piles will penetrate deeper into the glacial till or to the top of bedrock to develop the required axial capacity.

Assuming that the piles are driven to top of bedrock, the vertical pile lengths are estimated to be near 60 feet measured from the top of embankment to the top of the un-weathered bedrock (El. 859).

We recommend designing the piles with an 1/8-inch corrosion allowance. The bottom of the proposed pile caps will be above the normal high-water level in the river. To reduce the potential for pile corrosion above the static groundwater level, we recommend coating the piles with coal tar epoxy before driving. The coal tar epoxy coating should extend at least 15 feet below the final grade.

Wingwall Recommendations

For design of the wingwalls, the lateral earth pressure acting on the walls will depend on whether the support conditions permit sufficient outward rotation or displacement to reduce the pressure from at-rest to active pressure. We understand that the proposed wingwalls will be supported by the precast concrete abutment on one end and an additional driven soldier pile on the other. We expect the support provided by the precast concrete abutment will not permit rotation or appreciable movement of the wingwall. Therefore, at a minimum, we recommend using an at-rest lateral earth pressure equal to 60 psf/ft for design of the wingwall panels. Further from the abutment, the wingwall panel will experience increased lateral earth pressure due to railroad surcharge. We recommend evaluating the concrete wingwall panel assuming an average uniform pressure of 750 psf, which includes active earth pressure and lateral pressure from railroad surcharge. To promote drainage, we recommend providing weep holes in the wingwalls.

Based on a wingwall length of 10 feet, we recommend that the additional driven soldier pile used to support the wingwall be an H-Pile driven to a highest allowable tip elevation of approximately El. 894.5 (+/- 0.5 ft), which is about 25 feet below the top of the wingwall. Similar to the abutment and pier piles, we recommend designing the piles with an 1/8-inch corrosion allowance.

Scour

We understand that soil around the proposed pier at midspan and in front of the proposed abutments may be susceptible to scour during a flood event. We understand that HDR performed a scour analysis for the pier and abutments based on the grain size data provided in Appendix B (HDR, 2019). The results of the scour analysis indicated that the 100-year flood scour depths would be 5.3 feet at the south abutment, 2.2 feet at the north abutment, and 7.58 feet at the pier.

Scour below the proposed abutments could result in soil loss behind the abutments. We recommend providing slope armoring in front of the abutments to reduce the potential for scour in front of and below the proposed abutments. If scour protection is not provided for the center pier, the pier piles should be checked for buckling under full scour conditions.

Construction Considerations

Excavations for the abutments and wingwalls may require temporary excavation support and dewatering. To the extent possible, excavations should be maintained as shallow as possible to reduce the need for dewatering. Any necessary excavation support system should be designed in conjunction with a dewatering system by a Massachusetts-registered professional engineer experienced in excavation support and dewatering system design. The engineer should be engaged by the contractor and submit the designs for review before installation. All excavations should be made in accordance with OSHA standards.

Groundwater may be encountered during the excavation for the abutments and wingwalls. The specifications should require the contractor to maintain the groundwater level below the bottom of the excavation at all times. We recommend that the excavation subgrade be sloped slightly to a sump. Sumps should be located outside the limits of the proposed pile cap, and should extend at least 2 feet below the bottom of the excavation. Deeper sumps or closely spaced well points may be required to draw down the groundwater to maintain stability of the subgrades during subgrade preparation. The contractor should submit a dewatering plan prior to the start of excavation. We expect permits will be required for the proposed work.

Our borings indicated the presence of timber and possible cobbles and boulders in the sand and gravel and till layers that could affect driving the piles to the required depths, and to the required vertical / horizontal tolerances. The timber may be remnants from earlier deep foundation elements. Pre-augering, spudding, or removal of any near-surface obstructions may be necessary before driving the piles.

We recommend monitoring the existing structure for movement and potential damage during pile driving. Temporary support of the existing spans may be necessary to protect the existing structure during pile driving. Temporary support of the existing structure should be designed by a professional engineer engaged by the Contractor and designs should be submitted to the Engineer for review. During pile driving, we recommend that daily inspections of all connections and critical members of the existing bridge be performed by a professional engineer engaged by the Contractor.

Backfilling under the precast abutments will be difficult. Special consideration will need to be made to minimize loose soil below the abutment because compaction equipment will not fit under the structure. Therefore, we recommend considering using lean concrete or flowable fill to backfill up to 6 inches above the underside of the precast abutment. This will improve lateral performance of the structure and provide additional corrosion protection at the top of the abutment piles.

Soil placed as fill should be free of frost. The area behind the abutments should be backfilled with Gravel Borrow (MassDOT M1.03.0 Type B) or onsite soils that meet the Gravel Borrow Specifications. Backfill should be placed in maximum 12-inch thick loose lifts. Each lift should be compacted to at least 95 percent of the soil's maximum dry density per ASTM D698 at a moisture content within 2 percent of optimum.

Limitations

This letter was prepared for the use of HDR Engineering, Inc., exclusively. Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed structure. We cannot accept responsibility for designs based on our recommendations unless we are engaged

to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design. We also recommend that GEI observe and document the installation of the piles.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. We, therefore, recommend that GEI be engaged to make site visits during construction to: a) check that the subsurface conditions exposed during construction are in general conformance with our design assumptions and b) ascertain that, in general, the work is being performed in compliance with the contract documents.

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, express or implied, is made.

If you have any questions, please feel free to contact James Christensen at 781-721-4126 or Darren Clark at 207-797-8910.

Sincerely,

GEI CONSULTANTS, INC.

James L. Christensen, P.E.
Project Manager

Darren D. Clark, P.E. (ME)
Project Manager

JRG/JLC/DDC:bdp
Attachments
- Fig. 1 – Site Location Map
- Fig. 2 – Boring Location Plan
- Fig. 3 – Subsurface Profile A - A’
- Appendix A – Boring Logs
- Appendix B – Laboratory Test Results
- Appendix C – H-Pile Lateral Analysis

References

AREMA (2016). AREMA Railway Manual, Manual for Railway Engineering.

HDR (2019). “Determination of Scour at Bridge 77.16, Housatonic River Railroad over Codding Brook,” prepared for Massachusetts Department of Transportation – Rail and Transit Division, November 13.

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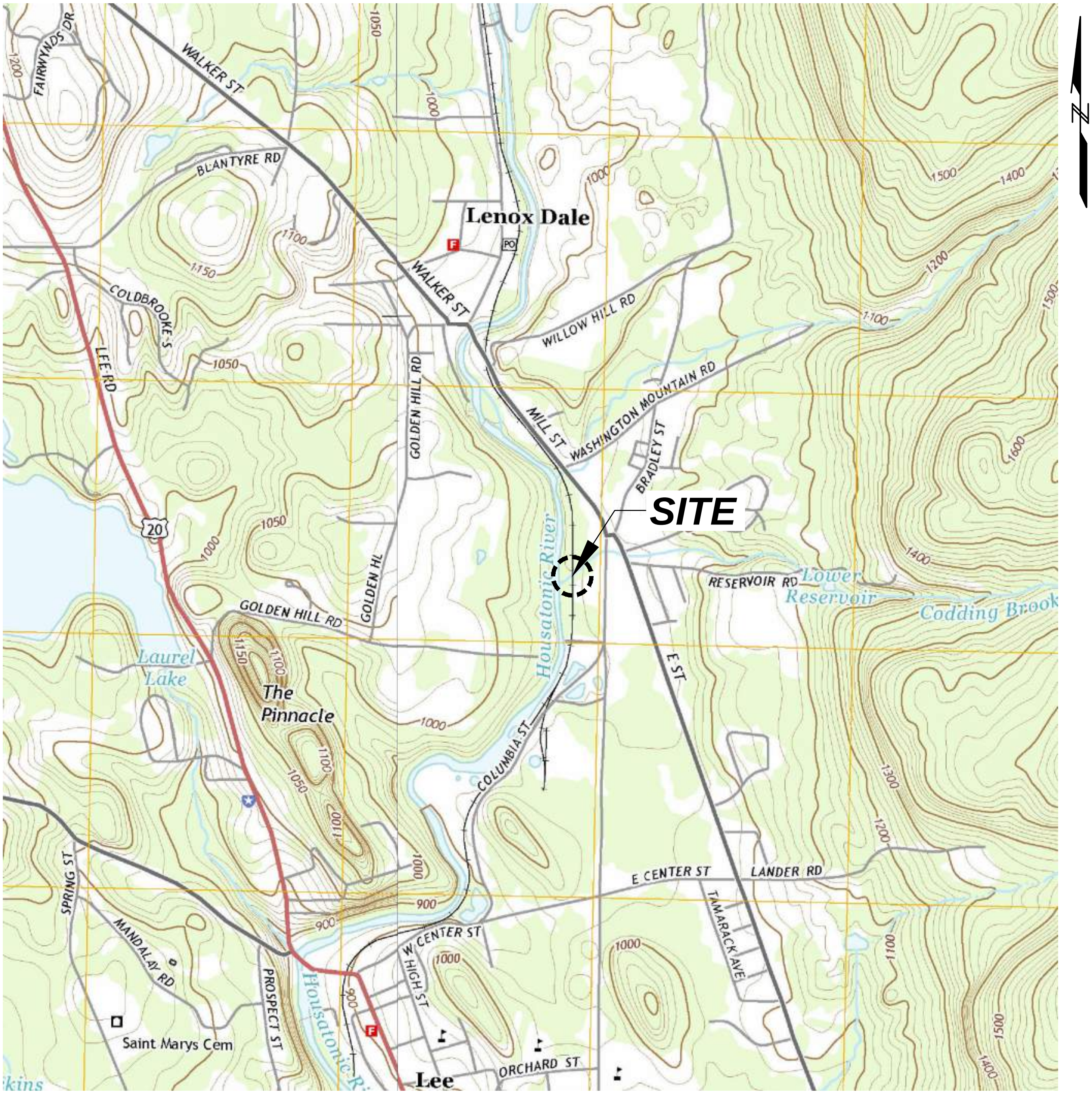
Figures

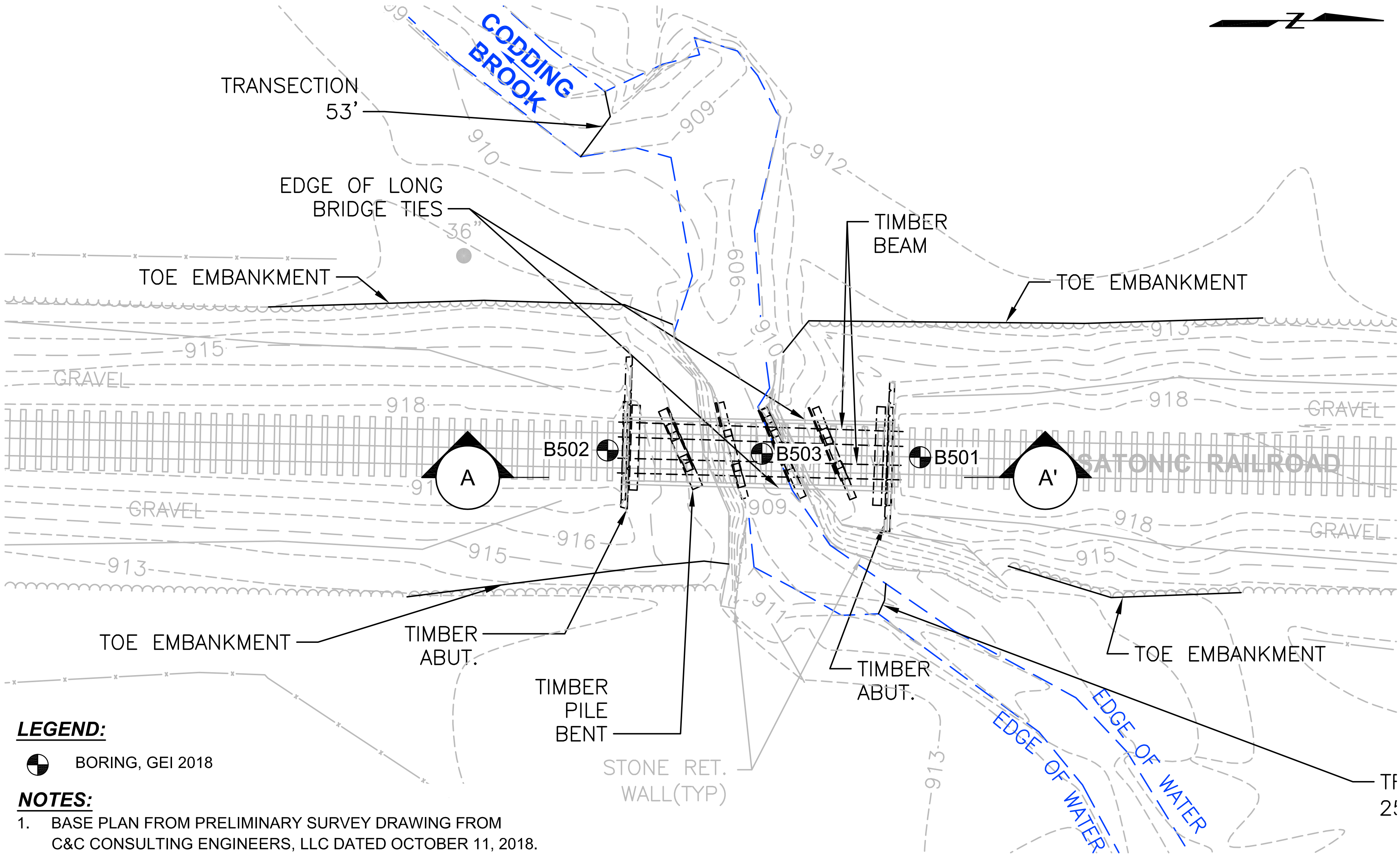


SCALE, FEET

This Image from U.S.G.S. Topographic 7.5 Minute Series
Stockbridge and East Lee, MA Quadrangles, 2015.
Datum is North American Vertical Datum of 1988 (NAVD88).
Contour Interval is 20 Feet.

QUADRANGLE LOCATION

MassDOT Berkshire Line Bridge MP 77.16 Lee, Massachusetts	GEI Consultants	SITE LOCATION MAP
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020 Fig. 1



LEGEND:

BORING, GEI 2018

NOTES:

1. BASE PLAN FROM PRELIMINARY SURVEY DRAWING FROM C&C CONSULTING ENGINEERS, LLC DATED OCTOBER 11, 2018.

0 20 40

SCALE: 1" = 20'

MassDOT Berkshire Line Bridge MP 77.16 Lee, Massachusetts	GEI Consultants	BORING LOCATION PLAN	
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020	Fig. 2

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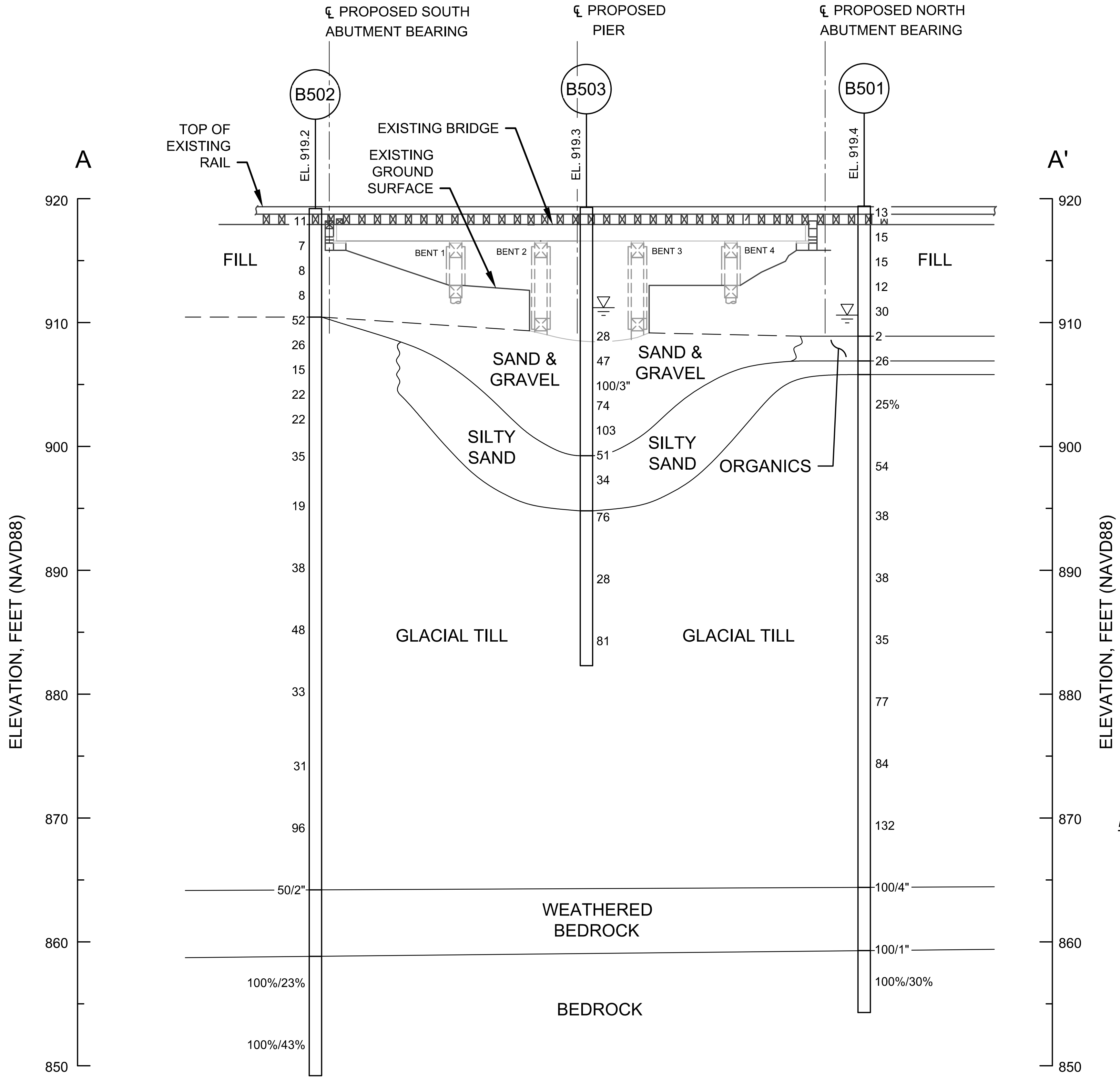

LEGEND:

B502	BORING NUMBER
EL. 919.2	ELEVATION OF GROUND SURFACE
	EXISTING GROUND SURFACE
	GROUNDWATER LEVEL MEASURED AT COMPLETION OF DRILLING
	STRATUM BOUNDARY
107	N-VALUE FROM STANDARD PENETRATION TEST, BLOWS PER FOOT
93%/40%	ROCK CORE RECOVERY/ROCK QUALITY DESIGNATION (RQD)

0 10 20

SCALE: 1" = 10'

NOTES

1. PROFILE AND BORING LOCATIONS ARE SHOWN IN FIG. 2.
2. GROUNDWATER LEVELS MAY VARY AT OTHER LOCATIONS AND AT OTHER TIMES OF THE YEAR AND LIKELY VARY WITH RIVER LEVELS. LEVELS MEASURED AT THE COMPLETION OF DRILLING MAY NOT REFLECT THE STABILIZED GROUNDWATER LEVEL.
3. THE BOUNDARIES BETWEEN SOIL STRATA MAY BE TRANSITIONAL. THE STRATA BOUNDARIES BETWEEN BORINGS MAY VARY SIGNIFICANTLY FROM THE INTERPOLATIONS SHOWN.

MassDOT Berkshire Line Bridge MP 77.16 Lee, Massachusetts	GEI Consultants	SUBSURFACE PROFILE A - A'
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020 Fig. 3

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Appendix A

Boring Logs

BORING INFORMATION

LOCATION: Bridge 77.16, North Abutment

GROUND SURFACE EL. (ft): 919.4 **DATE START/END:** 10/10/2018 - 10/12/2018

VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

TOTAL DEPTH (ft): 65.1 **DRILLER NAME:** Tim Van Ness / Dave

LOGGED BY: D. Litton **RIG TYPE:** CME Hi-Rail Mounted Truck Rig

BORING B501

DRILLING INFORMATION

HAMMER TYPE: Automatic **CASING I.D./O.D.:** 4 inch / 4.5 inch **CORE BARREL TYPE:** NX

AUGER I.D./O.D.: NA / NA **DRILL ROD O.D.:** 2.675 inch **CORE BARREL I.D./O.D.** 2 inch / 3 inch

DRILLING METHOD: Driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): ▼ 8.8 10/12/2018 8:15 am

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I.D./O.D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
		S1	0.5 to 2.5	24/1	3-6-7-7		SAND AND GRAVEL	S1: GRAVEL. Single piece of gravel in spoon.
		S2	2.5 to 4.5	24/0	6-7-8-8		SAND AND GRAVEL	S2: NO RECOVERY.
915	5	S3	4.5 to 6.5	24/2	8-8-7-11		SAND AND GRAVEL	S3: NARROWLY GRADED GRAVEL WITH SAND (GP); ~80% coarse gravel, 15% sand, ~5% non-plastic fines; tan; moist. 1.5 inch gravel piece stuck in tip. <FILL>
		S4	6.5 to 8.5	24/11	8-6-6-9		SAND AND GRAVEL	S4: SILTY SAND WITH GRAVEL (SM); ~60% fine to coarse sand, ~25% fine to coarse gravel, ~15% non-plastic fines; tan to gray; moist. <FILL>
910	10	S5	8.5 to 10.5	24/14	11-16-14-12		SAND AND GRAVEL	S5: SILTY SAND (SM); ~70% fine to coarse sand, ~25% non-plastic fines, ~5% fine gravel; tan; wet. <FILL>
		S6	10.5 to 12.5	24/16	1-1-1-1		ORGANICS	S6: SILTY SAND (SM); ~60% fine to medium sand, ~40% non-plastic fines; tan to gray; wet. Organics.
		S7	12.5 to 14.5	24/7	5-7-19-17		SS	S7 (0-4"): SILTY SAND (SM); ~65% fine to medium sand, ~35% non-plastic fines; gray; wet.
							GLACIAL TILL	S7 (4"-7"): WIDELY GRADED SAND WITH SILT (SW-SM) ~80% fine to coarse sand, ~10% non-plastic fines, ~10% fine gravel; tan; wet. 1 inch stone between layers.
905	15					Rig chatter ~15 ft.	GLACIAL TILL	
		C1	16 to 21	60/15		Core times (min/ft): 14, 2, 1, 3, 4	GLACIAL TILL	C1: COBBLES AND GRAVEL. Hard. White and Gray. 1 to 5 inches thick.
900	20						GLACIAL TILL	
		S8	21 to 23	24/12	17-22-32-65		GLACIAL TILL	S8: SILTY GRAVEL WITH SAND (GM); ~50% fine to coarse gravel, ~35% fine to coarse sand, ~15% non-plastic fines; gray; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16

CITY/STATE: Lee, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 77.16, North Abutment
GROUND SURFACE EL. (ft): 919.4
VERTICAL DATUM: NAVD 88
DATE START/END: 10/10/2018 - 10/12/2018
DRILLING COMPANY: Aquifer Drilling and Testing, Inc.

BORING B501

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	25	S9	25 to 27	24/7	33-22-16-29			S9: SILTY GRAVEL WITH SAND (GM); ~50% fine to coarse gravel, ~30% fine to coarse sand, ~20% non-plastic fines; black; wet.
890	30	S10	30 to 32	24/18	17-17-21-25			S10: SILTY SAND WITH GRAVEL (SM); ~45% fine to coarse sand, ~40% fine to coarse gravel, ~15% non-plastic fines; tan; wet.
						Rig chatter ~33 ft.		
885	35	S11	35 to 37	24/15	13-18-17-24			S11: SILTY SAND (SM); ~80% fine to coarse sand, ~15% non-plastic fines, ~5% fine gravel; tan; wet.
						Rig chatter ~38 ft.	GLACIAL TILL	
880	40	S12	40 to 41.9	23/14	57-54-23-70/5"			S12: SILTY GRAVEL WITH SAND (GM); ~50% fine to coarse gravel, ~35% fine to coarse sand, ~15% non-plastic fines; tan to gray; wet.
875	45	S13	45 to 47	24/13	19-52-32-33			S13: SILTY GRAVEL WITH SAND (GM); Similar to S12.
870	50	S14	50 to 52	24/16	15-52-80-77			S14: SILTY SAND WITH GRAVEL (SM); ~50% fine to coarse sand, ~35% fine to coarse gravel, ~15% non-plastic fines; tan to gray; wet.
865	55							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16
CITY/STATE: Lee, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 77.16, North Abutment			**BORING B501**
GROUND SURFACE EL. (ft): 919.4	**DATE START/END:** 10/10/2018 - 10/12/2018		
VERTICAL DATUM: NAVD 88	**DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.		

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
		S15	55 to 55.3	4/3	100/4"		DECOMPOSED ROCK	S15: DECOMPOSED ROCK; White rock and drilling mud.
860	60	S16	60 to 60.1	1/1	100/1"	Core times (min/ft): 5, 4, 5, 12, 7		S16: DECOMPOSED ROCK; 1 inch white decomposed rock.
855	65	C2	60.1 to 65.1	60/60	30		DOLOMITIC MARBLE	C2: DOLOMITIC MARBLE; medium hard. White to Light Gray. Fractures at ~20 degrees from 0 to 12", ~60 degrees from 12 to 24 inches, horizontal fractures at ~2 to 3 inches o.c. from 24 to 48 inches, and fractures at ~60 degrees from 48 to 60 inches.
								Bottom of boring at depth 65.1 ft. Borehole backfilled with tremie grout to existing grade.
850	70							
845	75							
840	80							
835	85							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16

CITY/STATE: Lee, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION

LOCATION: Bridge 77.16, South Abutment
GROUND SURFACE EL. (ft): 919.2 **DATE START/END:** 10/12/2018 - 10/16/2018
VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.
TOTAL DEPTH (ft): 70.0 **DRILLER NAME:** Dave
LOGGED BY: D. Litton **RIG TYPE:** CME Hi-Rail Mounted Truck Rig

BORING B502

DRILLING INFORMATION

HAMMER TYPE: Automatic **CASING I.D./O.D.:** 4 inch / 4.5 inch **CORE BARREL TYPE:** NX
AUGER I.D./O.D.: NA / NA **DRILL ROD O.D.:** 2.675 inch **CORE BARREL I.D./O.D.** 2 inch / 3 inch
DRILLING METHOD: Driven casing and washed with rotary tooling.
WATER LEVEL DEPTHS (ft): Not measured

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I.D./O.D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
							SAND AND GRAVEL	(0 - 4"): 4"RAIL. (4" - 12"): BALLAST.
		S1	1 to 3	24/4	3-5-6-6			S1: SILTY GRAVEL WITH SAND (GM); ~50% fine to coarse gravel, ~35% fine to coarse sand, ~15% non-plastic fines; black; moist. <FILL>
915		S2	3 to 5	24/14	3-3-4-4			S2: SILTY SAND (SM); ~60% fine to coarse sand, ~30% non-plastic fines, ~10% fine gravel; brown; moist. <FILL>
	5	S3	5 to 7	24/16	4-4-4-4			S3: SILTY SAND (SM); Similar to S2. Trace organics. <FILL>
		S4	7 to 9	24/16	4-4-4-3			S4: SILTY SAND (SM); Similar to S2. Wet. <FILL>
910	10	S5	9 to 11	24/11	20-29-23-9	Rollerbit grinding ~9.5 ft.	GLACIAL TILL	S5: SILTY GRAVEL WITH SAND (GM); ~55% fine to coarse gravel, 30% fine to coarse sand, ~15% non-plastic fines; brown to dark gray; wet.
		S6	11 to 13	24/12	7-15-11-6			S6: SILTY GRAVEL WITH SAND (GM); Similar to S5.
905		S7	13 to 15	24/10	5-3-12-18			S7: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~50% fine to coarse sand, ~40% fine to coarse gravel, ~10% non-plastic fines; brown; wet.
	15	S8	15 to 17	24/10	18-19-3-7			S8: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); Similar to S7.
		S9	17 to 19	24/8	8-8-14-22	Drive 4 inch casing to 20 ft.		S9: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); Similar to S7.
900	20	S10	20 to 22	24/11	20-15-20-16			S10: WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); ~50% fine to coarse gravel, ~40% fine to coarse sand, ~10% non-plastic fines; tan to gray; wet.
						Rig chatter.		

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16
CITY/STATE: Lee, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 77.16, South Abutment
GROUND SURFACE EL. (ft): 919.2 **DATE START/END:** 10/12/2018 - 10/16/2018
VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

BORING B502

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	25	S11	24 to 26	24/9	10-9-10-7	Rig chatter.	GLACIAL TILL	S11: WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); ~55% fine to coarse gravel, ~35% fine to coarse sand, ~10% non-plastic fines; tan; wet.
890	30	S12	29 to 31	24/2	11-22-16-16	Rig chatter.		S12: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~55% fine to coarse sand, ~35% fine to coarse gravel, ~10% non-plastic fines; tan; wet.
885	35	S13	34 to 36	24/16	14-23-25-26			S13: SILTY SAND (SM); ~70% fine to coarse sand, ~25% non-plastic fines, ~5% fine gravel; tan; wet.
880	40	S14	39 to 41	24/14	10-14-19-22			S14: SILTY SAND (SM); ~60% fine to coarse sand, ~30% non-plastic fines, ~10% fine gravel; tan; wet.
875	45	S15	45 to 46.7	20/8	11-15-16-50/2"	Rig chatter.		S15: SILTY SAND WITH GRAVEL (SM); ~50% fine to coarse sand, ~30% non-plastic fines, ~20% fine to coarse gravel; gray; wet.
870	50	S16	50 to 52	24/18	30-50-46-42			S16: SILTY GRAVEL WITH SAND (GM); ~45% fine to coarse gravel, ~40% fine to coarse sand, ~15% non-plastic fines; gray; wet.
865	55							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16
CITY/STATE: Lee, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 77.16, South Abutment
GROUND SURFACE EL. (ft): 919.2 **DATE START/END:** 10/12/2018 - 10/16/2018
VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
		S17	55 to 55.2	2/2	50/2"		WEATHERED ROCK	S17: WEATHERED ROCK; ~90% weathered rock, ~10% fine to coarse sand; tan, gray, red; wet.
860	60	C1	60 to 65	60/60	23	Core times (min/ft): 5, 4, 4, 4, 4	DOLOMITIC MARBLE	C1: DOLOMITIC MARBLE; Moderate hard. Light Gray. Highly fractured. Fractured horizontal to vertical.
855	65	C2	65 to 70	60/60	43	Core times (min/ft): 4, 3, 3, 4, 4	DOLOMITIC MARBLE	C2 (0 - 22"): DOLOMITIC MARBLE; Similar to C1. C2 (22" - 60") : DOLOMITIC MARBLE; Moderate hard. Gray. Highly fractured. Fractured at 0 - 45 degree planes.
850	70							Bottom of boring at depth 70 ft. Borehole backfilled with tremie grout to existing grade.
845	75							
840	80							
835	85							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16
CITY/STATE: Lee, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION

LOCATION: Bridge 77.16, Mid-span

GROUND SURFACE EL. (ft): 919.3 **DATE START/END:** 10/16/2018 - 10/17/2018

VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

TOTAL DEPTH (ft): 37.0 **DRILLER NAME:** Tim Van Ness

LOGGED BY: D. Litton **RIG TYPE:** CME Hi-Rail Mounted Truck Rig

BORING B503

DRILLING INFORMATION

HAMMER TYPE: Automatic **CASING I.D./O.D.:** 4 inch / 4.5 inch **CORE BARREL TYPE:** NA

AUGER I.D./O.D.: NA / NA **DRILL ROD O.D.:** 2.675 inch **CORE BARREL I.D./O.D.** NA / NA

DRILLING METHOD: Spun and driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): ⊻ 8.1 10/17/2018 10:24 am

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I.D./O.D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
915	5							
910	10							10'-5" to Stream Bed
		S1	10.4 to 12.4	24/4	15-13-15-20	Rig chatter.	SAND AND GRAVEL	S1: WIDELY GRADED GRAVEL WITH SAND (GW); ~80% fine to coarse gravel, ~15% fine to coarse sand, ~5% non-plastic fines; brown; wet. Timbers in Tip.
		S2	12.4 to 14.4	24/8	10-9-38-68		SAND AND GRAVEL	S2: WIDELY GRADED GRAVEL WITH SAND (GW); ~65% fine to coarse gravel up to 2 inches, ~30% fine to coarse sand, ~5% non-plastic fines; dark brown; wet.
905	15	S3	14.4 to 15.2	9/9	74-100/3"		SAND AND GRAVEL	S3: WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); ~50% fine to coarse gravel, ~40% fine to coarse sand, ~10% non-plastic fines; dark brown; wet. ~4 inches timber in spoon.
		S4	16 to 18	24/18	38-38-36-38		SAND AND GRAVEL	S4: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~55% fine to coarse sand, 35% fine to coarse gravel, ~10% non-plastic fines; brown; wet. ~6 inches of timber in top of spoon.
900		S5	18 to 20	24/10	19-52-51-40	Rollerbit through timber.	SAND AND GRAVEL	S5: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); Similar to S4. No wood.
	20	S6	20 to 22	24/11	19-30-21-14	Open hole after ~20 ft.	SILTY SAND	S6: SILTY SAND WITH GRAVEL (SM); ~65% fine to coarse sand, ~20% non-plastic fines, ~15% fine gravel; gray; wet.
		S7	22 to 24	24/19	12-16-18-21		SILTY SAND	S7: SILTY SAND WITH GRAVEL (SM); Similar to S6. Tan.

NOTES: S1 - S4 taken with 3" O.D. Split Spoon sampler. Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16

CITY/STATE: Lee, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 77.16, Mid-span		**BORING**
GROUND SURFACE EL. (ft): 919.3	**DATE START/END:** 10/16/2018 - 10/17/2018	**B503**
VERTICAL DATUM: NAVD 88	**DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.	**PAGE 2 of 2**

Elev. (ft)	Depth (ft)	Sample Information: Sample No.	Sample Information: Depth (ft)	Sample Information: Pen./ Rec. (in)	Sample Information: Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895								
	25	S8	25 to 27	24/10	16-41-35-43		GLACIAL TILL	S8: WIDELY GRADED SAND WITH GRAVEL (SW); ~70% fine to coarse sand, ~25% fine to coarse gravel, ~5% non-plastic fines; tan to gray at 6 inches into spoon. Wet.
890								
	30	S9	30 to 32	24/11	15-14-14-19	Lost mud at ~30 ft. Remix and continue.		S9: SILTY SAND WITH GRAVEL (SM); ~65% fine to coarse sand, ~25% fine gravel, ~20% non-plastic fines; tan; wet.
						Roller bit grinding.		
885								
	35	S10	35 to 37	24/3	30-37-44-45			S10: WIDELY GRADED GRAVEL WITH SAND (GW); ~80% fine to coarse gravel, ~15% fine to coarse sand, ~5% non-plastic fines; tan; wet.
								Bottom of boring at depth 37 ft. Borehole backfilled with tremie grout to existing grade.
880	40							
875	45							
870	50							
865	55							

NOTES: S1 - S4 taken with 3" O.D. Split Spoon sampler. Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineeers, LLC dated October 11, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 77.16
CITY/STATE: Lee, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

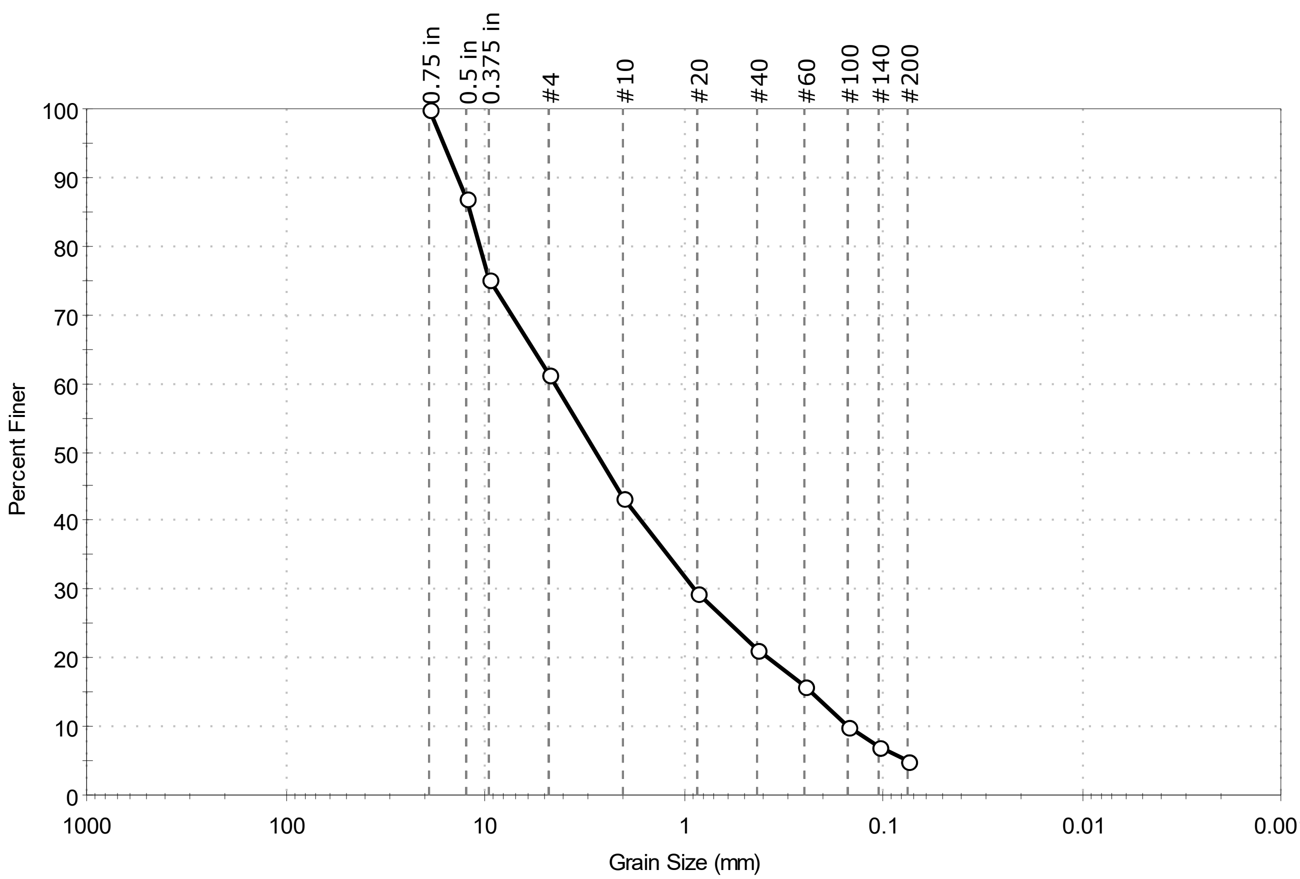
GEI WOBURN STD 1-LOCATION-LAYER NAME HOUSATONIC BR 77.16.GPJ 11/7/19

Appendix B

Laboratory Test Results

Client:	GEI Consultants, Inc.		
Project:	MassDOT Berkshire Line Bridge 77.16		
Location:	Lee, MA	Project No:	GTX-310238
Boring ID: B503	Sample Type: jar	Tested By:	ckg
Sample ID: S1	Test Date: 07/11/19	Checked By:	bfs
Depth : 10.4-12.4	Test Id: 513026		
Test Comment:	---		
Visual Description:	Moist, reddish brown sand with silt and gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	38.6	56.3	5.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	87		
0.375 in	9.50	75		
#4	4.75	61		
#10	2.00	43		
#20	0.85	30		
#40	0.42	21		
#60	0.25	16		
#100	0.15	10		
#140	0.11	7		
#200	0.075	5.1		

Coefficients

D_{85} =11.9097 mm — D_{30} =0.8757 mm

D_{60} =4.4331 mm — D_{15} =0.2296 mm

D_{50} =2.7482 mm — D_{10} =0.1488 mm

C_u =29.792 — C_c =1.163

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (1))

Sample/Test Description

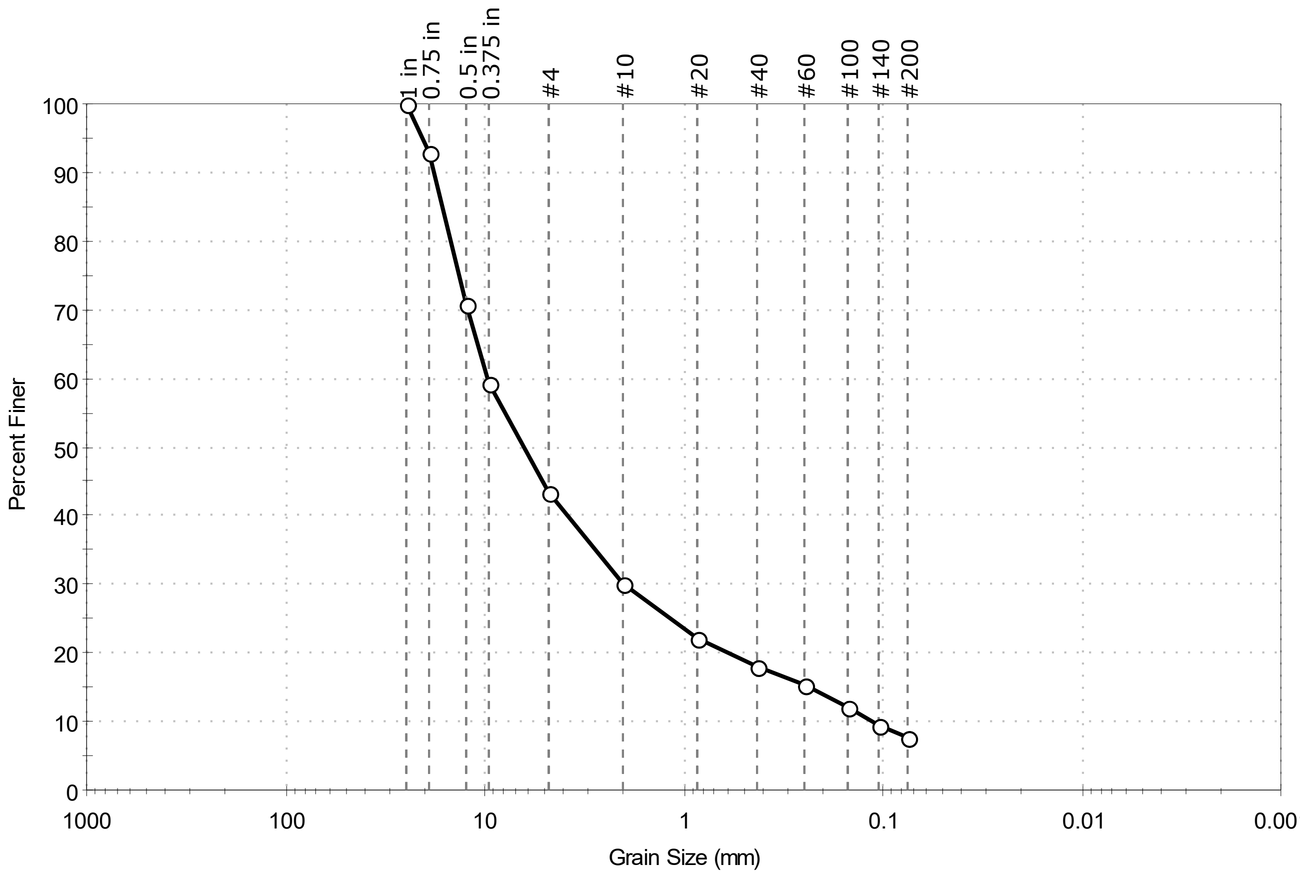
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	GEI Consultants, Inc.		
Project:	MassDOT Berkshire Line Bridge 77.16		
Location:	Lee, MA	Project No:	GTX-310238
Boring ID: B503	Sample Type: jar	Tested By:	ckg
Sample ID: S3	Test Date: 07/11/19	Checked By:	bfs
Depth : 14.4-15.2	Test Id: 513027		

Test Comment: ---
Visual Description: Moist, dark reddish brown gravel with silt and sand
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	56.5	35.9	7.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	93		
0.5 in	12.50	71		
0.375 in	9.50	59		
#4	4.75	43		
#10	2.00	30		
#20	0.85	22		
#40	0.42	18		
#60	0.25	15		
#100	0.15	12		
#140	0.11	10		
#200	0.075	7.6		

Coefficients

D_{85} =16.3520 mm
D_{30} =1.9929 mm
D_{60} =9.6393 mm
D_{15} =0.2319 mm
D_{50} =6.3121 mm
D_{10} =0.1131 mm
C_u =85.228
C_c =3.643

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (1))

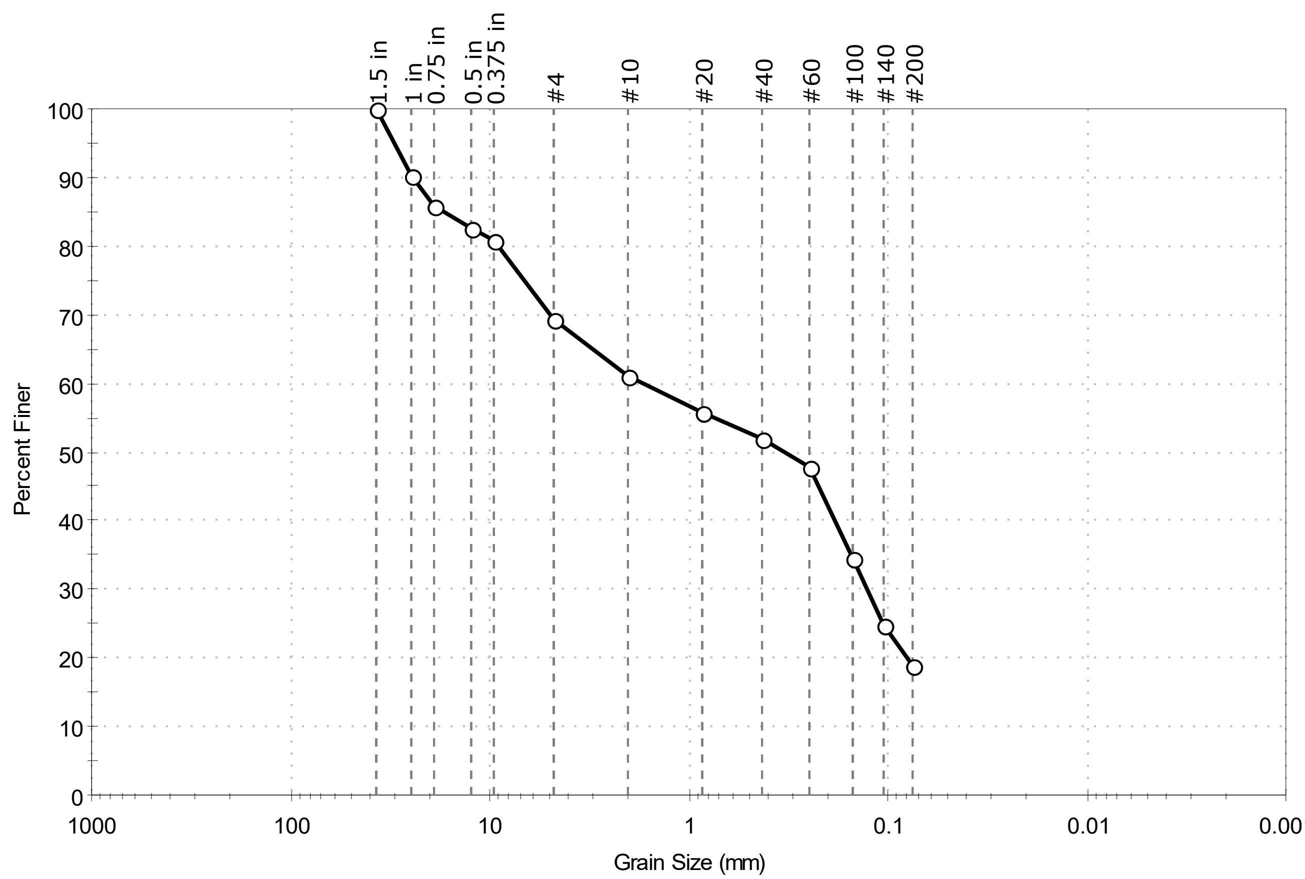
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	GEI Consultants, Inc.				
Project:	MassDOT Berkshire Line Bridge 77.16				
Location:	Lee, MA			Project No:	GTX-310238
Boring ID:	B503	Sample Type:	jar	Tested By:	ckg
Sample ID:	S5	Test Date:	07/11/19	Checked By:	bfs
Depth :	18-20	Test Id:	513028		
Test Comment:	---				
Visual Description:	Moist, light olive brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	30.6	50.4	19.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	90		
0.75 in	19.00	86		
0.5 in	12.50	83		
0.375 in	9.50	81		
#4	4.75	69		
#10	2.00	61		
#20	0.85	56		
#40	0.42	52		
#60	0.25	48		
#100	0.15	34		
#140	0.11	25		
#200	0.075	19		

Coefficients

D_{85} =17.1901 mm　　D_{30} =0.1280 mm

D_{60} =1.7085 mm　　D_{15} =N/A

D_{50} =0.3293 mm　　D_{10} =N/A

C_u =N/A　　C_c =N/A

Classification

ASTM　N/A

AASHTO　Silty Gravel and Sand (A-2-4 (0))

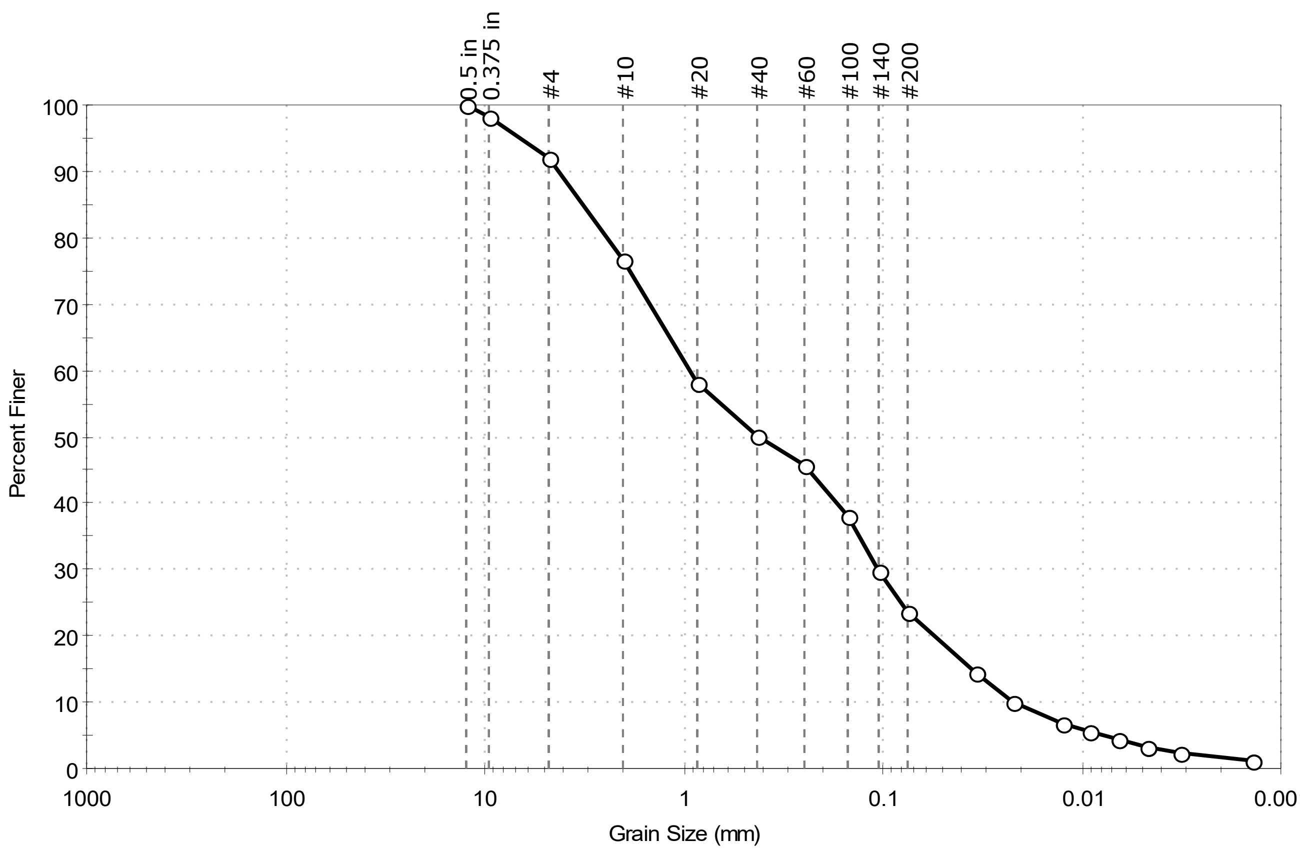
Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Client:	GEI Consultants, Inc.				
Project:	MassDOT Berkshire Line Bridge 77.16				
Location:	Lee, MA			Project No:	GTX-310238
Boring ID:	B503	Sample Type:	jar	Tested By:	ckg
Sample ID:	S7	Test Date:	07/11/19	Checked By:	bfs
Depth :	22-24	Test Id:	513029		
Test Comment:	---				
Visual Description:	Moist, olive silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	8.1	68.2	23.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	98		
#4	4.75	92		
#10	2.00	77		
#20	0.85	58		
#40	0.42	50		
#60	0.25	46		
#100	0.15	38		
#140	0.11	30		
#200	0.075	24		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0344	14		
---	0.0220	10		
---	0.0127	7		
---	0.0092	6		
---	0.0066	4		
---	0.0047	3		
---	0.0032	2		
---	0.0014	1		

Coefficients

D_{85} =3.2147 mm D_{30} =0.1070 mm

D_{60} =0.9327 mm D_{15} =0.0362 mm

D_{50} =0.4138 mm D_{10} =0.0221 mm

C_u =42.204 C_c =0.555

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Appendix C

H-Pile Lateral Analysis

C1. Abutment Pile Analysis

C2. Pier Pile Analysis

C1. Abutment Pile Analysis

GEI Consultants	Client	HDR Engineering, Inc.				
	Project	MassDOT Berkshire Line Bridge 77.16				
	By	J. Giampa	Chk.	J. Christensen	App.	
	Date	10/30/2019	Date	11/7/2019	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 77.16 – Pile Analyses					

OBJECTIVE

This calculation presents estimated pile lengths for a steel HP14 section at the abutments at the Housatonic Railroad, Bridge 77.16, Codding Brook Bridge in Lee, Massachusetts.

ANALYTICAL METHODOLOGY

We estimated pile lengths at the bridge abutments for a steel HP14 section as described below:

1. Developed a soil profile that is representative of the conditions at the abutments at Bridge 77.16.
2. Estimated unit weights and strength properties to the soils based on site-specific explorations.
3. Computed the applied lateral load acting perpendicular and parallel to the pile cap at the bridge abutment, based on the unfactored longitudinal loads and revised bridge layout provided by HDR Engineering, Inc. on September 30, 2019.
4. Computed the additional passive lateral resistance of the abutment when the abutment is displaced 1 inch towards the embankment fill.
5. Prepared two LPILE models to represent a typical abutment pile: 1. Loaded parallel to the pile cap, and 2. Loaded perpendicular to the pile cap.
6. Obtained lateral pile-head deflection, bending moment, shear force, and mobilized soil reaction versus depth for each LPILE model.
7. Compared the pile deflection computed from LPILE to the maximum deflection criteria presented in AREMA (2016).
8. Provided recommended preliminary driving criteria based on AREMA (2016).

ELEVATION DATUM

Elevations used in this document are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88).

ASSUMPTIONS

From the computed longitudinal and vertical loads for the bridge substructure provided by HDR Engineering, Inc. in an email on September 30, 2019, it appears that the structure will rely on the bridge abutments to resist the longitudinal load. Therefore, we modeled a typical abutment pile only because the longitudinal load at the bridge piers will equal zero.

The following assumptions were made for this analysis:

- Groundwater and river elevation, El. 913.
- Fixed-head loading condition at the bridge abutment when loaded parallel to the pile cap.
- Pinned-head loading condition at the bridge abutment when loaded perpendicular to the pile cap.
- The load parallel to the pile cap is applied on the weak axis of the pile section.
- The load perpendicular to the pile cap is applied on the strong axis of the pile section.
- Passive earth pressure can be developed behind each bridge abutment.
- Steel specification for HP14: ASTM A572 Gr 50.

SOIL PROFILE

Soil properties used in this calculation are based on GEI borings B501 and B503 performed from October 10 through October 17, 2018 by Aquifer Drilling and Testing, Inc.

Figure 1 presents the general geometry and soil profile used for each LPILE model.

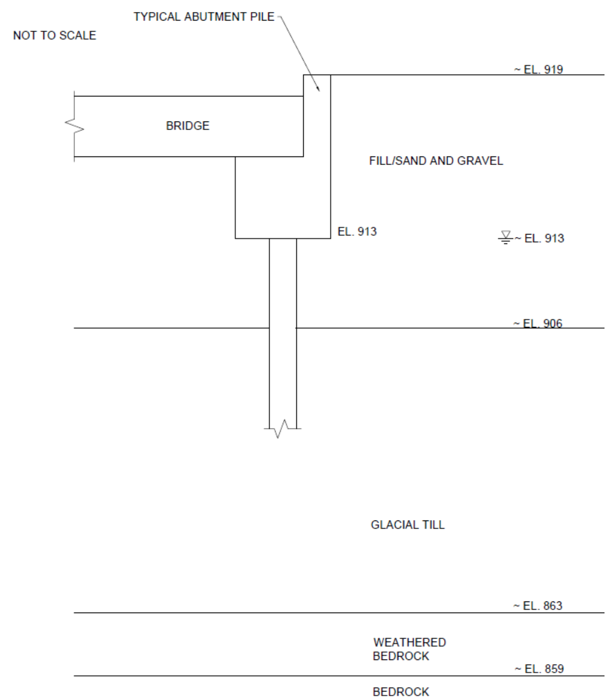


Figure 1. General Geometry and Soil Profile.

In LPILE, we modeled the pile head at approximately elevation, El. 913.

LPILE SOIL PARAMETERS

Table 1 presents the soil properties used in LPILE. The LPILE soil model and soil modulus parameter was selected based on recommendations in the LPILE Technical Manual (Ensoft 2018).

Table 1. Soil Properties used in LPILE Analyses

Soil Type	LPILE Soil Model	Effective Soil Unit Weight (pcf)	Friction Angle (deg)	Soil Modulus Parameter, k (pci)
Fill / Sand and Gravel	Sand (Reese)	62.6	30	60
Glacial Till	Sand (Reese)	72.6	38	125

Pcf = pounds per cubic foot; pci = pound cubic inch

The pile spacing at the abutment is equal to about 4.8 times the width (B) of the pile. We applied a P-multiplier (group reduction factor) in LPILE equal to 0.90 to account for group interaction effects based on the 2017 AASHTO LRFD Bridge Design Manual for pile spacing less than or equal to 5B.

STEEL H-PILES

Based on the soil profile shown in Figure 1 above, we expect the steel HP14 piles will be driven to refusal in the glacial till or on the top of rock. Due to the potential for pile damage during driving, we recommend using an HP14x117 which is the heaviest HP14 available. While a lighter HP14 may be able to resist the combined axial and flexural loads, the HP14x117 will provide additional stiffness and will improve lateral performance.

DESIGN LOADS

We received the pile loads from HDR Engineering, Inc. in an email on September 30, 2019.

Unfactored - Vertical Load

Load	Abutment	Pier
Dead (kips) (Sub-Structure)	37.21	24.19
Dead (kips) (Super Structure)	60.84	121.68
Live (kips)	200.00	262.20
Impact (kips)	100.62	131.92
Total	398.67	539.98

(Loads provided 09/30/19)

Unfactored - Longitudinal Load

Load (Kips)	Abutment	Pier
Braking/Traction Force (LF)	111.80	-
Bearing Resistance Force (F)	6.08	-
Earth Pressure (E)	15.81	-
Live Load Surcharge (LF)	22.09	-
Total	155.79	0.00

(Loads provided 09/30/19)

LPILE LOAD CASES

The lateral loading in the direction of the bridge was provided as an equal load of 51.93 kips for each pile because the pile cap beam will allow near-uniform load sharing between the three proposed piles. However, the proposed bridge has a skew of approximately 65 degrees as shown in Figure 2. To account for this, we developed two loading cases for the LPILE analyses.

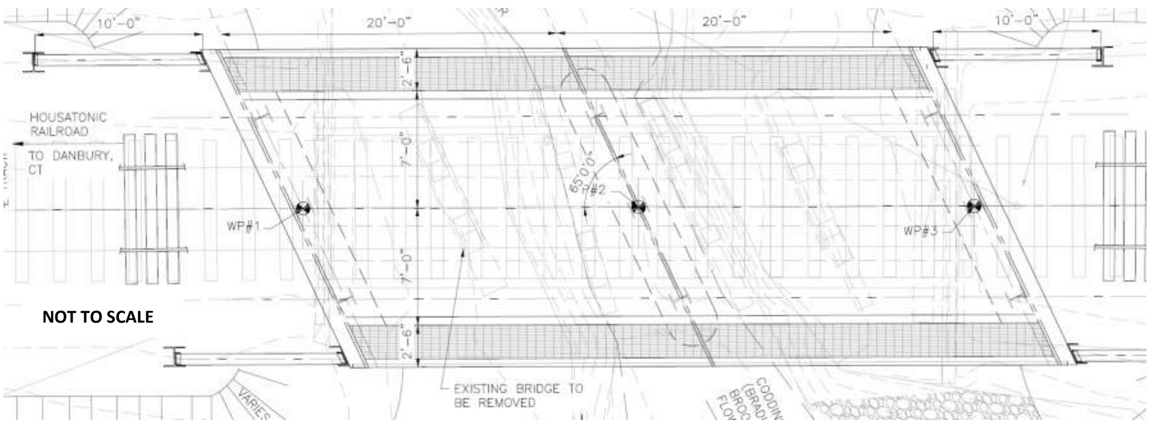


Figure 2. Proposed Bridge Layout Provided by HDR Engineering, Inc.

1. Loading Parallel to the Pile Cap – We calculated the lateral load in the direction parallel to the pile cap beam, applied to the weak axis of the pile. We modelled the pile head as fixed against rotation because the cap beam will provide rotation fixity for loading parallel to the cap beam.
   - Applied Lateral Load (per pile) = 51.93 kips*sin(25 deg) = 21.95 kips

2a. Perpendicular to the Pile Cap – We calculated the lateral load in the direction perpendicular to the pile cap beam, applied to the strong axis of the pile. We modelled the pile head as a pinned connection. By modelling the pile head as pinned we have assumed that passive earth pressures can be developed behind the bridge abutment and provide additional resistance to the applied lateral load perpendicular to the pile cap.

    We computed the passive soil pressure we expect to develop on the back of the abutment using research performed by MassDOT and UMass Amherst for integral abutments provided in the MassDOT LRFD Bridge Manual Section 3.10.8.

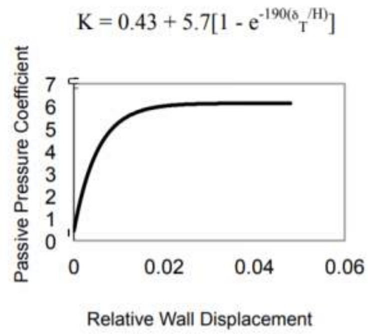


Figure 3.10.8-1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

Assuming a deformation of 1-inch at the bridge bearing elevation and an abutment height of 4.5 feet, we estimated a passive earth pressure coefficient, K_p, of 6 will be developed. Based on the revised sketches prepared by HDR, we understand the abutment will be about 15-feet wide. The resulting passive lateral pressure behind the abutment will be:

P_p = 0.5*(4.5ft^2)*120pcf*6*15ft = 109 kip

Therefore, the applied net lateral load perpendicular to the pile cap beam was calculated.

- Applied Lateral Load (per pile) = 51.93 kips*cos(25 deg) – 109 kips / 3 piles = 10.73 kips

The computed maximum resultant deflection for Load Cases 1 and 2a, presented above, was computed to equal 0.49-inch which underestimates the total lateral load resisted by the piles. Therefore, we iterate (in 2b) below to better estimate the lateral pile loads and the overall behavior of the pile-supported abutment.

2b. Perpendicular to the Pile Cap – To better model the pile behavior perpendicular to the cap beam, we iterated Load Case 2a to estimate a net lateral load such that the assumed deflection at the bridge bearing elevation, used to compute the passive soil pressure, would equal the resultant deflection output from LPILE.

Using the procedure presented above in Load Case 2a and through iteration, we assumed a deformation of approximately 0.58-inch at the bridge bearing elevation and

an abutment height of 4.5 feet, we estimated a K_p of 5.4 will be developed. The resulting passive lateral pressure behind the abutment will be:

$P_p = 0.5*(4.5ft^2)*120pcf*5.4*15ft = 98.4$ kip

Therefore, the applied net lateral load perpendicular to the pile cap beam was calculated.

- Applied Lateral Load (per pile) = 51.93 kips*cos(25 deg) – 98.4 kips / 3 piles = 14.26 kips

To capture p-delta effects in the LPILE models, we applied an axial load equal to 133 kips per pile for the abutment piles.

–

Table 2. Load Cases

Load Case	Pile Head Condition	Section Axis	Axial Load (kips)	Lateral at Pile Head (kips)
1. Parallel to Pile Cap	Fixed Head	Weak	133	21.95
2b. Perpendicular to Pile Cap	Pinned Head	Strong	133	14.26

RESULTS

The results of these analyses are based on the assumed steel HP14x117 pile section and a pile length of 25 feet. These analyses assume the piles will be advanced a minimum of 16 feet into glacial till (highest allowable tip elevations of approximately El. 888 at the north abutment, El. 894 at the south abutment, and El. 878 at the pier). LPILE computed lateral pile deflection, bending moment, shear force, and mobilized soil reaction versus depth for each soil profile (Appendix A).

The computed resultant lateral deflections are less than 1-inch which satisfies the deformation criteria specified in AREMA Section 2.2.3.j.3. Based on our evaluation, a 3-pile bent at the Bridge Abutment will resist the applied longitudinal loads.

Table 3. LPILE Results

Load Case	Deflection at top of Pile (in)	Pile-Head Rotation (rad)	Max Deflection at Top of Abutment (in)	Max Resultant Deflection (in)	Max Moment (kip-ft)	Max Shear (kips)
1. Parallel to Pile Cap	0.35	0.00	0.35	0.69	110.8	21.95
2b. Perpendicular to Pile Cap	0.40	0.00381	0.60		84.15	14.26

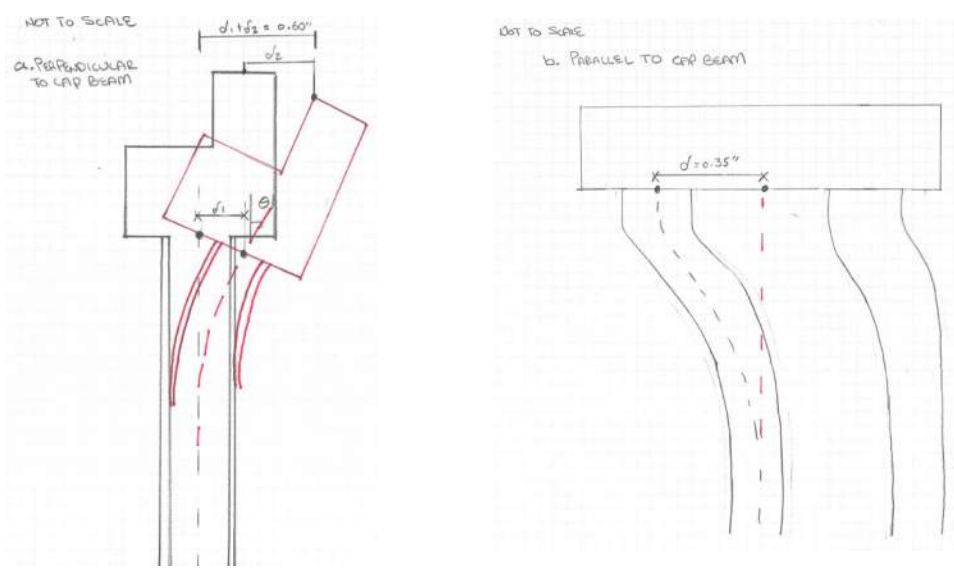


Figure 3. Deflected Pile Shape Subject to: a. Loading Perpendicular to Pile Cap; b. Loading Parallel to Pile Cap

REFERENCES

1. AREMA (2016). AREMA Railway Manual, Manual for Railway Engineering.
2. Ensoft, Inc. (2018). Technical Manual for LPILE 2018: A program to Analyze Deep Foundations Under Lateral Loading.
3. Highway Division Massachusetts Department of Transportation (2013). MassDOT LRFD Bridge Manual – Part I Design Guidelines, 2013 Edition.
4. AASHTO (2017). AASHOT LRFD Bridge Design Specifications, 8th Edition

GEI Consultants	Client	HDR Engineering, Inc.				
	Project	MassDOT Berkshire Line Bridge 77.16				
	By	J. Giampa	Chk.	J. Christensen	App.	
	Date	10/30/2019	Date	11/7/2019	Date	

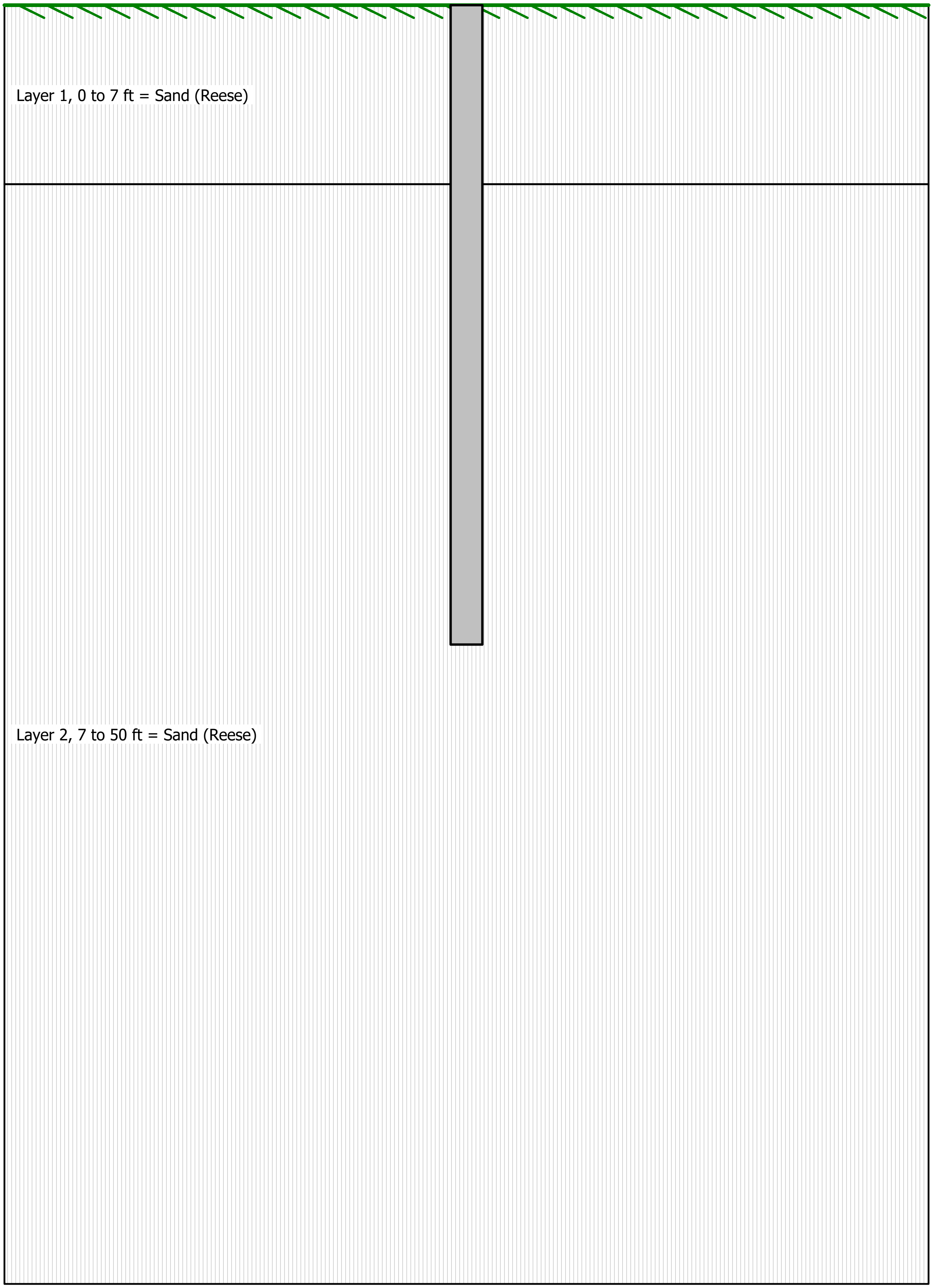
Project No.	1703257	Document No.	N/A
Subject	Bridge 77.16 – Pile Analyses		

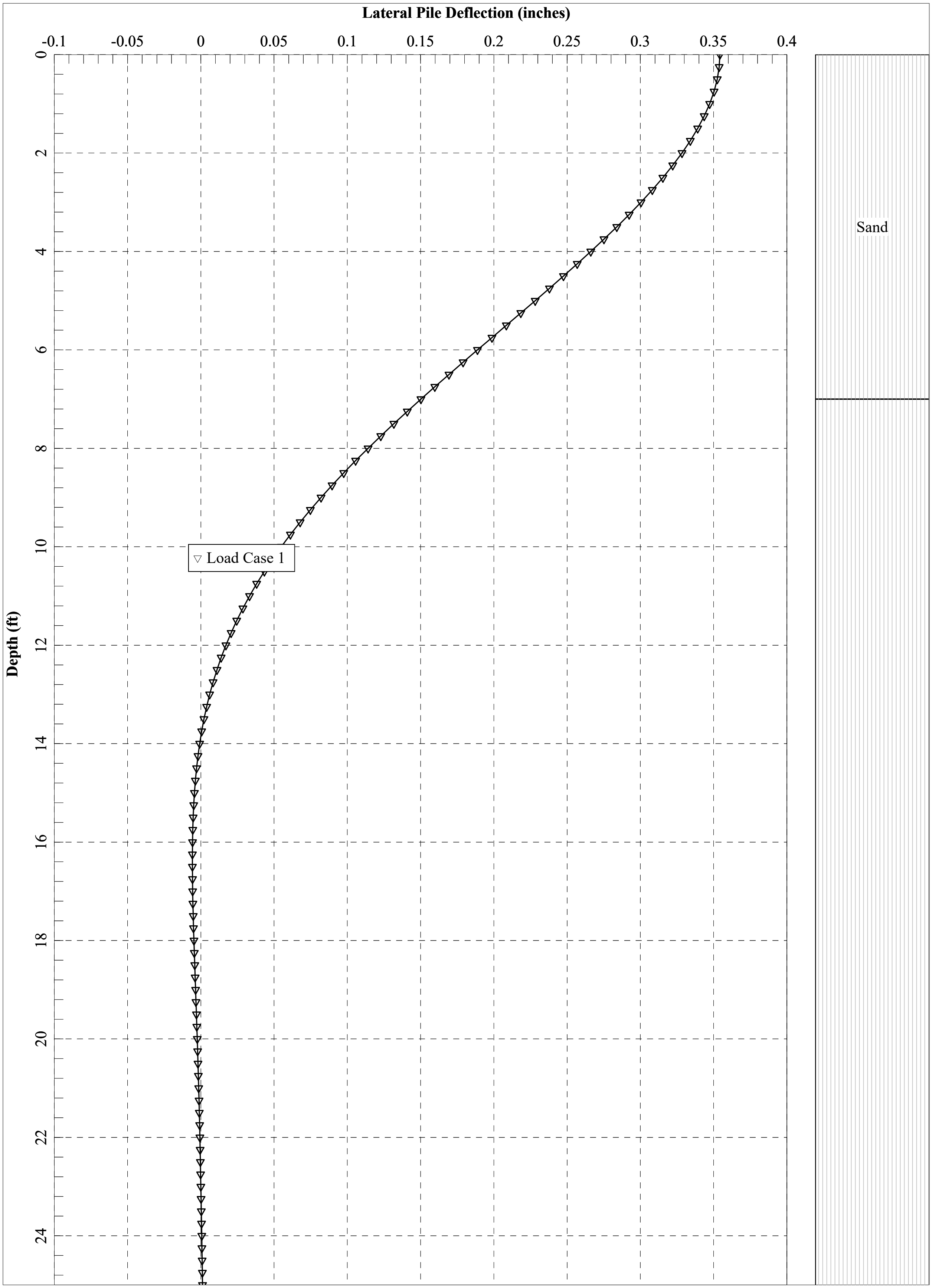
ATTACHMENT: LPILE OUTPUT

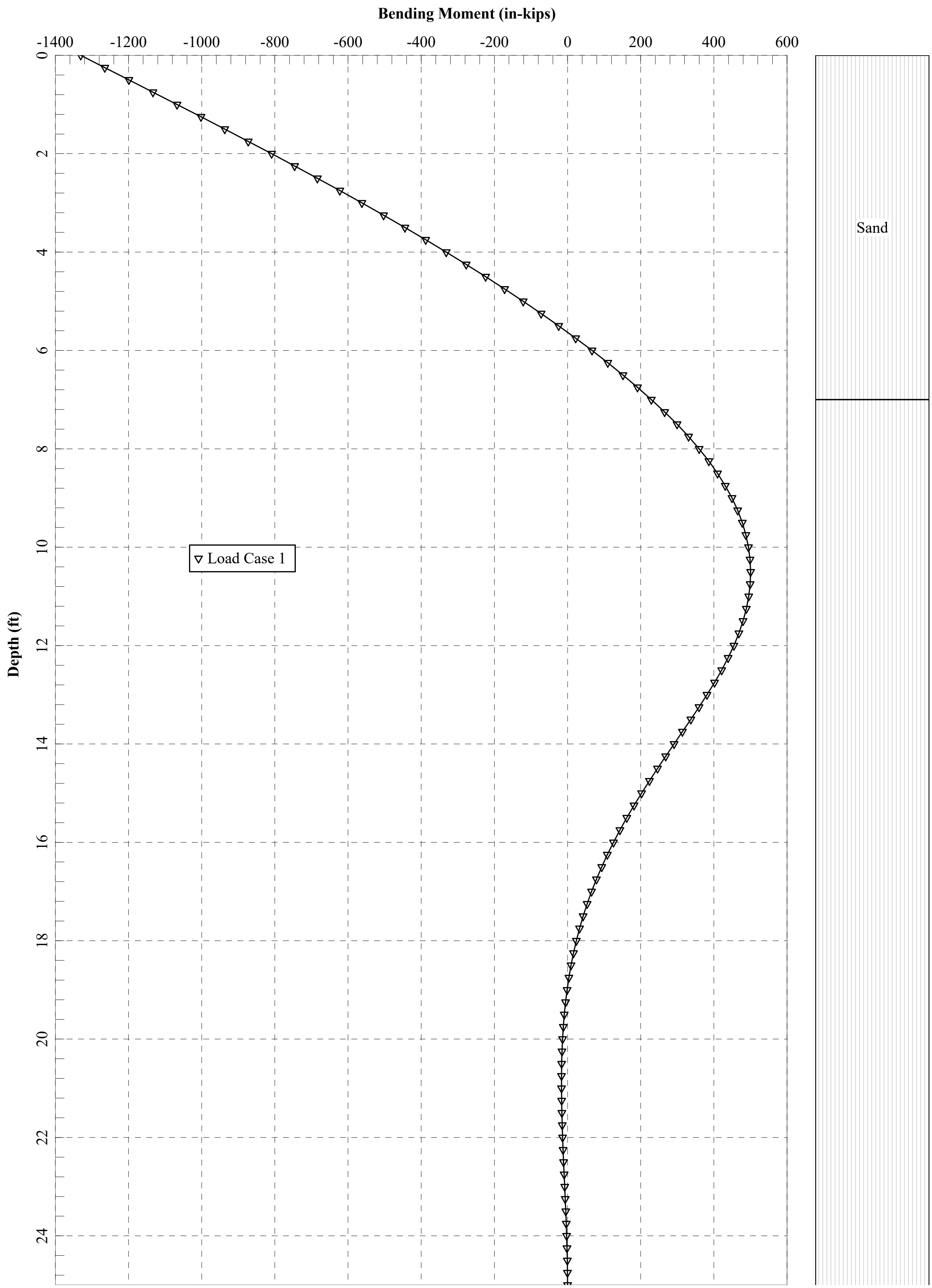
Pile Head Condition: Fixed
HP14x117 (weak axis)

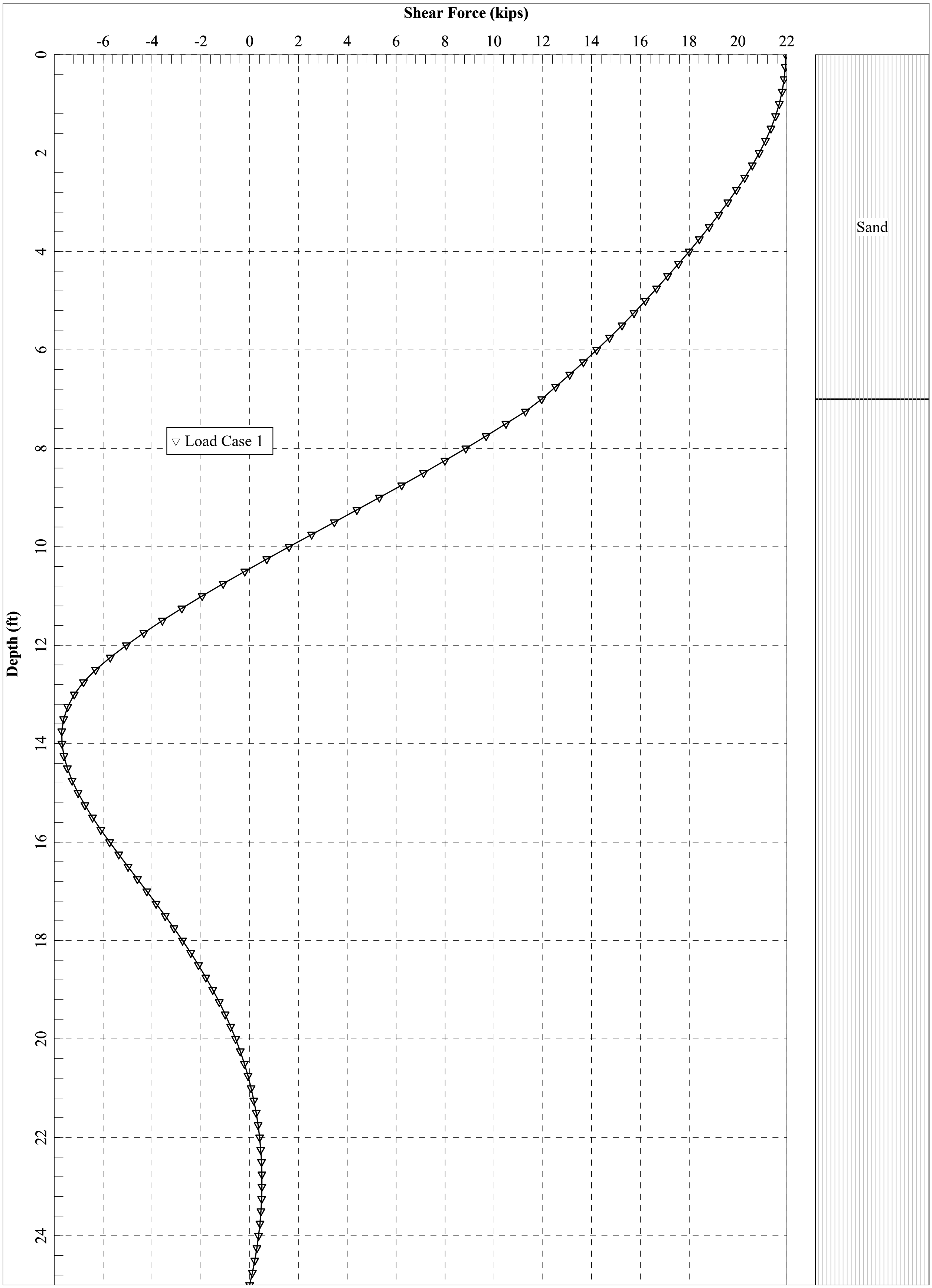
Load Case 1: Parallel to Pile Cap

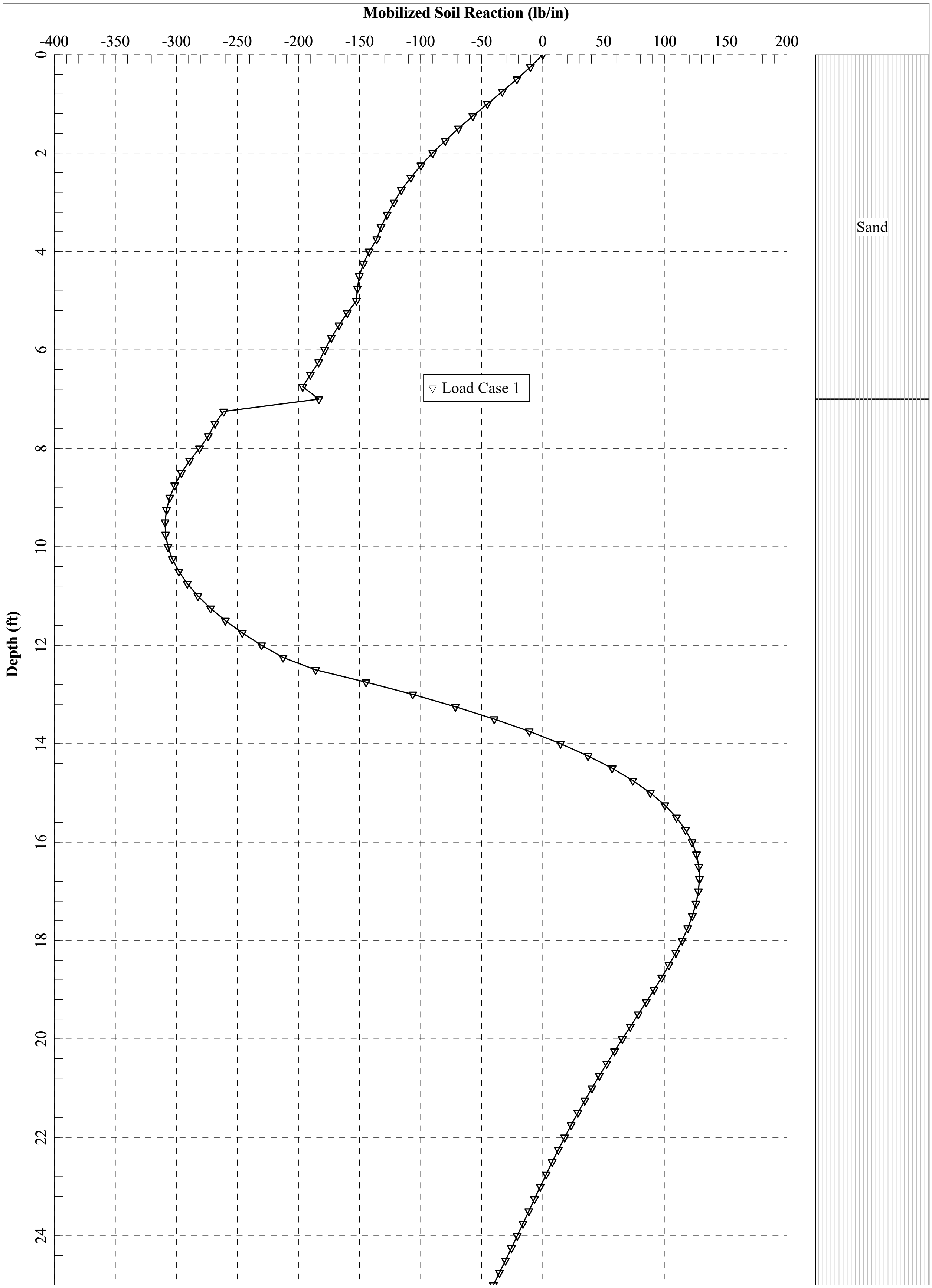
Axial = 133 kips
Shear = 21.95 kips




Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
▽ Load Case 1
Sand


Bending Moment (in-kips)
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand


Shear Force (kips)
-6
-4
-2
0
2
4
6
8
10
12
14
16
18
20
22
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand


Mobilized Soil Reaction (lb/in)
-400
-350
-300
-250
-200
-150
-100
-50
0
50
100
150
200
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand

==

LPile for Windows(Beta), Version 2018-10.009

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

This copy of LPile is being used by:

Joseph Giampa
GEI Consultants, Inc.

Serial Number of Security Device: 239146454

This copy of LPile is licensed for exclusive use by:

GEI Consultants, Woburn, MA

Use of this program by any entity other than GEI Consultants, Woburn, MA
is a violation of the software license agreement.

Files Used for Analysis

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\PIle Length Estimate\LPILE 2019-10-03 and 2019-10-30\

Name of input data file:
1. Parallel to Cap - Br. Abutment (weak axis, HP14x117).lp10

Name of output report file:
1. Parallel to Cap - Br. Abutment (weak axis, HP14x117).lp10

Name of plot output file:

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117).lp10

Name of runtime message file:
1. Parallel to Cap - Br. Abutment (weak axis, HP14x117).lp10

Date and Time of Analysis

Date: November 11, 2019   Time: 10:50:53

Problem Title

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: JRG

Description: HP14x117_Bridge Abutment (parallel)

Program Options and Settings
----

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

```
Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------
```

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

```
Number of pile sections defined                         =          1
Total length of pile                                    =       25.000 ft
Depth of ground surface below top of pile               =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.
```

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.9000
2	25.000	14.9000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H weak axis steel pile
   Length of section                                    =    25.000000 ft
   Pile width                                           =    14.200000 in
   Shear capacity of section                            =       0.0000 lbs
```

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

Pile Batter Angle                                       =        0.000 degrees
                                                        =        0.000 radians
```

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =      0.0000 ft
   Distance from top of pile to bottom of layer       =    7.000000 ft
   Effective unit weight at top of layer              =   62.600000 pcf
   Effective unit weight at bottom of layer           =   62.600000 pcf
   Friction angle at top of layer                     =   30.000000 deg.
   Friction angle at bottom of layer                  =   30.000000 deg.
   Subgrade k at top of layer                         =   60.000000 pci
   Subgrade k at bottom of layer                      =   60.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    7.000000 ft
   Distance from top of pile to bottom of layer       =   50.000000 ft
   Effective unit weight at top of layer              =   72.600000 pcf
   Effective unit weight at bottom of layer           =   72.600000 pcf
   Friction angle at top of layer                     =   38.000000 deg.
   Friction angle at bottom of layer                  =   38.000000 deg.
   Subgrade k at top of layer                         =  125.000000 pci
   Subgrade k at bottom of layer                      =  125.000000 pci


 (Depth of the lowest soil layer extends 25.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type           Layer      Effective    Angle of
```

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

Layer Num.	Name (p-y Curve Type)	Depth ft	Unit Wt. pcf	Friction deg.	kpy pci
1	Sand	0.00	62.6000	30.0000	60.0000
	(Reese, et al.)	7.0000	62.6000	30.0000	60.0000
2	Sand	7.0000	72.6000	38.0000	125.0000
	(Reese, et al.)	50.0000	72.6000	38.0000	125.0000

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.9000	1.0000
2	25.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

```
-----   ----   --------------------   ----------------------   ---------------   ---------------
   1     2     V =       21950. lbs   S =       0.0000 in/in           133000.          No
```

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel H Weak Axis:

```
Length of Section                                           =    25.000000 ft
Flange Width                                                =    14.900000 in
Section Depth                                               =    14.200000 in
Flange Thickness                                            =     0.805000 in
Web Thickness                                               =     0.805000 in
Yield Stress of Pipe                                        =    50.000000 ksi
Elastic Modulus                                             =       29000. ksi
Cross-sectional Area                                        =    34.123950 sq. in.
Moment of Inertia                                           =   444.363799 in^4
Elastic Bending Stiffness                                   =    12886550. kip-in^2
Plastic Modulus, Z                                          =    91.398684in^3
Plastic Moment Capacity = Fy Z                              =        4570.in-kip
```

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 1706.197 kips
Nominal Axial Tensile Capacity = -1706.197 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	133.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 133.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000492	63.4463072	12886018.	34.7464857	4.9506740	
0.00000985	126.8926144	12886018.	21.0982428	6.0037920	
0.00001477	190.3389216	12886018.	16.5488286	7.0569102	
0.00001969	253.7852288	12886018.	14.2741214	8.1100282	
0.00002462	317.2315359	12886018.	12.9092971	9.1631464	
0.00002954	380.6778431	12886018.	11.9994143	10.2162645	
0.00003447	444.1241503	12886018.	11.3494980	11.2693826	
0.00003939	507.5704575	12886018.	10.8620607	12.3225007	
0.00004431	571.0167647	12886018.	10.4829429	13.3756188	
0.00004924	634.4630719	12886018.	10.1796486	14.4287369	
0.00005416	697.9093791	12886018.	9.9314987	15.4818550	
0.00005908	761.3556863	12886018.	9.7247071	16.5349731	

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

0.00006401	824.8019934	12886018.	9.5497297	17.5880912	
0.00006893	888.2483006	12886018.	9.3997490	18.6412093	
0.00007385	951.6946078	12886018.	9.2697657	19.6943274	
0.00007878	1015.	12886018.	9.1560304	20.7474455	
0.00008370	1079.	12886018.	9.0556756	21.8005637	
0.00008863	1142.	12886018.	8.9664714	22.8536818	
0.00009355	1205.	12886018.	8.8866571	23.9067999	
0.00009847	1269.	12886018.	8.8148243	24.9599180	
0.0001034	1332.	12886018.	8.7498327	26.0130361	
0.0001083	1396.	12886018.	8.6907493	27.0661542	
0.0001132	1459.	12886018.	8.6368037	28.1192723	
0.0001182	1523.	12886018.	8.5873536	29.1723904	
0.0001231	1586.	12886018.	8.5418594	30.2255085	
0.0001280	1650.	12886018.	8.4998648	31.2786266	
0.0001329	1713.	12886018.	8.4609810	32.3317447	
0.0001379	1776.	12886018.	8.4248745	33.3848628	
0.0001428	1840.	12886018.	8.3912581	34.4379809	
0.0001477	1903.	12886018.	8.3598829	35.4910991	
0.0001526	1967.	12886018.	8.3305318	36.5442172	
0.0001576	2030.	12886018.	8.3030152	37.5973353	
0.0001625	2094.	12886018.	8.2771662	38.6504534	
0.0001674	2157.	12886018.	8.2528378	39.7035715	
0.0001723	2221.	12886018.	8.2298996	40.7566896	
0.0001773	2284.	12886018.	8.2082357	41.8098077	
0.0001822	2348.	12886018.	8.1877429	42.8629258	
0.0001871	2411.	12886018.	8.1683286	43.9160439	
0.0001920	2474.	12886018.	8.1499099	44.9691620	
0.0002019	2601.	12886018.	8.1157679	47.0753982	
0.0002117	2728.	12886018.	8.0848020	49.1816344	
0.0002216	2852.	12872966.	8.0583845	50.0000000	Y
0.0002314	2968.	12827446.	8.0389430	50.0000000	Y
0.0002413	3078.	12757075.	8.0252873	50.0000000	Y
0.0002511	3181.	12668117.	8.0163949	50.0000000	Y
0.0002610	3276.	12552349.	8.0094428	50.0000000	Y
0.0002708	3360.	12407683.	8.0029162	50.0000000	Y
0.0002806	3436.	12242166.	7.9961256	50.0000000	Y
0.0002905	3504.	12062222.	7.9899159	50.0000000	Y
0.0003003	3565.	11871352.	7.9835531	50.0000000	Y
0.0003102	3621.	11675002.	7.9774040	50.0000000	Y
0.0003200	3673.	11475256.	7.9714394	50.0000000	Y

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

0.0003299	3719.	11273872.	7.9656327	50.0000000	Y
0.0003397	3762.	11072240.	7.9599367	50.0000000	Y
0.0003496	3801.	10871815.	7.9543795	50.0000000	Y
0.0003594	3836.	10673581.	7.9489286	50.0000000	Y
0.0003693	3869.	10478273.	7.9435307	50.0000000	Y
0.0003791	3900.	10286677.	7.9381868	50.0000000	Y
0.0003890	3928.	10099334.	7.9328915	50.0000000	Y
0.0003988	3954.	9915509.	7.9280523	50.0000000	Y
0.0004087	3979.	9736736.	7.9232892	50.0000000	Y
0.0004185	4002.	9561981.	7.9181478	50.0000000	Y
0.0004284	4023.	9391172.	7.9135804	50.0000000	Y
0.0004382	4043.	9226042.	7.9090490	50.0000000	Y
0.0004481	4061.	9064109.	7.9043803	50.0000000	Y
0.0004579	4079.	8907342.	7.8999756	50.0000000	Y
0.0004677	4095.	8754696.	7.8956031	50.0000000	Y
0.0004776	4110.	8606273.	7.8912870	50.0000000	Y
0.0004874	4125.	8462119.	7.8871750	50.0000000	Y
0.0004973	4138.	8321956.	7.8829137	50.0000000	Y
0.0005071	4151.	8185596.	7.8790319	50.0000000	Y
0.0005170	4164.	8053447.	7.8748486	50.0000000	Y
0.0005268	4175.	7924368.	7.8711171	50.0000000	Y
0.0005367	4186.	7799438.	7.8673361	50.0000000	Y
0.0005465	4196.	7677696.	7.8633797	50.0000000	Y
0.0005564	4206.	7559488.	7.8600074	50.0000000	Y
0.0005662	4215.	7444242.	7.8561547	50.0000000	Y
0.0005761	4224.	7332440.	7.8525534	50.0000000	Y
0.0005859	4232.	7223571.	7.8493132	50.0000000	Y
0.0006253	4262.	6816016.	7.8357490	50.0000000	Y
0.0006647	4287.	6449537.	7.8232139	50.0000000	Y
0.0007041	4308.	6118534.	7.8114917	50.0000000	Y
0.0007435	4326.	5818465.	7.8004074	50.0000000	Y
0.0007829	4341.	5545576.	7.7898170	50.0000000	Y
0.0008223	4355.	5296029.	7.7803618	50.0000000	Y
0.0008616	4366.	5067631.	7.7711688	50.0000000	Y
0.0009010	4377.	4857316.	7.7622690	50.0000000	Y
0.0009404	4386.	4663703.	7.7541242	50.0000000	Y
0.0009798	4394.	4484407.	7.7462381	50.0000000	Y
0.0010192	4401.	4318423.	7.7386802	50.0000000	Y
0.0010586	4408.	4163778.	7.7317355	50.0000000	Y
0.0010980	4414.	4020018.	7.7250215	50.0000000	Y

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

0.0011374	4419.	3885483.	7.7183667	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	133.0000000000	4419.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	18694.
2	7.0000	5.3682	Yes	No	18694.	N.A.

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 21950.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 133000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3543	-1330702.	21950.	0.00	26208.	1.29E+10	0.00	0.00	0.00
0.2500	0.3538	-1264791.	21935.	-3.02E-04	25102.	1.29E+10	-9.9806	84.6281	0.00
0.5000	0.3525	-1198851.	21888.	-5.89E-04	23997.	1.29E+10	-21.1452	179.9808	0.00
0.7500	0.3503	-1132991.	21807.	-8.60E-04	22893.	1.29E+10	-33.0427	283.0039	0.00
1.0000	0.3473	-1067322.	21690.	-0.00112	21792.	1.29E+10	-45.2303	390.7078	0.00
1.2500	0.3436	-1001962.	21536.	-0.00136	20696.	1.29E+10	-57.2416	499.8209	0.00
1.5000	0.3392	-937023.	21347.	-0.00158	19607.	1.29E+10	-68.9549	609.9485	0.00
1.7500	0.3341	-872619.	21124.	-0.00179	18527.	1.29E+10	-79.7569	716.2194	0.00
2.0000	0.3284	-808850.	20869.	-0.00199	17458.	1.29E+10	-90.0540	822.6897	0.00
2.2500	0.3221	-745818.	20584.	-0.00217	16402.	1.29E+10	-99.7392	928.8501	0.00
2.5000	0.3154	-683613.	20273.	-0.00234	15359.	1.29E+10	-108.0098	1027.	0.00
2.7500	0.3081	-622318.	19937.	-0.00249	14331.	1.29E+10	-115.7437	1127.	0.00
3.0000	0.3004	-562006.	19581.	-0.00263	13320.	1.29E+10	-121.7685	1216.	0.00

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

3.2500	0.2924	-502738.	19207.	-0.00275	12326.	1.29E+10	-127.3902	1307.	0.00
3.5000	0.2839	-444569.	18817.	-0.00286	11351.	1.29E+10	-132.3641	1399.	0.00
3.7500	0.2752	-387551.	18415.	-0.00296	10395.	1.29E+10	-135.9309	1482.	0.00
4.0000	0.2662	-331720.	17998.	-0.00304	9459.	1.29E+10	-142.1019	1602.	0.00
4.2500	0.2569	-277137.	17564.	-0.00311	8544.	1.29E+10	-146.9163	1715.	0.00
4.5000	0.2475	-223851.	17119.	-0.00317	7651.	1.29E+10	-150.1922	1820.	0.00
4.7500	0.2379	-171895.	16666.	-0.00322	6779.	1.29E+10	-151.7137	1913.	0.00
5.0000	0.2282	-121289.	16209.	-0.00325	5931.	1.29E+10	-152.4912	2005.	0.00
5.2500	0.2184	-72045.	15741.	-0.00327	5105.	1.29E+10	-159.9882	2198.	0.00
5.5000	0.2086	-24233.	15250.	-0.00328	4304.	1.29E+10	-166.8717	2400.	0.00
5.7500	0.1987	22079.	14741.	-0.00328	4268.	1.29E+10	-173.0592	2613.	0.00
6.0000	0.1889	66832.	14213.	-0.00327	5018.	1.29E+10	-178.4720	2835.	0.00
6.2500	0.1791	109972.	13670.	-0.00325	5741.	1.29E+10	-183.5108	3075.	0.00
6.5000	0.1693	151450.	13110.	-0.00322	6437.	1.29E+10	-190.2594	3371.	0.00
6.7500	0.1597	191201.	12530.	-0.00318	7103.	1.29E+10	-196.4670	3690.	0.00
7.0000	0.1502	229167.	11960.	-0.00313	7740.	1.29E+10	-183.2335	3659.	0.00
7.2500	0.1409	265463.	11293.	-0.00308	8348.	1.29E+10	-261.3015	5563.	0.00
7.5000	0.1318	299382.	10499.	-0.00301	8917.	1.29E+10	-268.4298	6111.	0.00
7.7500	0.1228	330857.	9685.	-0.00294	9445.	1.29E+10	-273.8436	6688.	0.00
8.0000	0.1141	359837.	8853.	-0.00286	9930.	1.29E+10	-281.0783	7388.	0.00
8.2500	0.1057	386254.	7998.	-0.00277	10373.	1.29E+10	-289.0891	8205.	0.00
8.5000	0.09752	410033.	7120.	-0.00268	10772.	1.29E+10	-295.8740	9102.	0.00
8.7500	0.08963	431112.	6224.	-0.00258	11125.	1.29E+10	-301.3531	10087.	0.00
9.0000	0.08204	449438.	5314.	-0.00248	11433.	1.29E+10	-305.4540	11170.	0.00
9.2500	0.07476	464973.	4394.	-0.00237	11693.	1.29E+10	-308.1114	12364.	0.00
9.5000	0.06781	477692.	3468.	-0.00226	11906.	1.29E+10	-309.2680	13682.	0.00
9.7500	0.06119	487583.	2540.	-0.00215	12072.	1.29E+10	-308.8737	15142.	0.00
10.0000	0.05492	494649.	1617.	-0.00203	12191.	1.29E+10	-306.8862	16765.	0.00
10.2500	0.04899	498907.	701.5184	-0.00192	12262.	1.29E+10	-303.2698	18573.	0.00
10.5000	0.04340	500390.	-200.3794	-0.00180	12287.	1.29E+10	-297.9955	20598.	0.00
10.7500	0.03817	499144.	-1084.	-0.00169	12266.	1.29E+10	-291.0393	22875.	0.00
11.0000	0.03328	495232.	-1944.	-0.00157	12200.	1.29E+10	-282.3812	25452.	0.00
11.2500	0.02875	488733.	-2776.	-0.00146	12091.	1.29E+10	-272.0022	28388.	0.00
11.5000	0.02455	479740.	-3573.	-0.00134	11941.	1.29E+10	-259.8810	31761.	0.00
11.7500	0.02068	468364.	-4332.	-0.00123	11750.	1.29E+10	-245.9890	35677.	0.00
12.0000	0.01715	454730.	-5047.	-0.00113	11521.	1.29E+10	-230.2815	40284.	0.00
12.2500	0.01393	438982.	-5711.	-0.00102	11257.	1.29E+10	-212.6847	45800.	0.00
12.5000	0.01102	421279.	-6309.	-9.21E-04	10961.	1.29E+10	-185.9621	50625.	0.00
12.7500	0.00840	401863.	-6805.	-8.26E-04	10635.	1.29E+10	-144.6350	51638.	0.00
13.0000	0.00607	381108.	-7182.	-7.34E-04	10287.	1.29E+10	-106.4673	52650.	0.00

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

13.2500	0.00400	359359.	-7449.	-6.48E-04	9922.	1.29E+10	-71.4836	53662.	0.00
13.5000	0.00218	336934.	-7615.	-5.67E-04	9546.	1.29E+10	-39.6769	54675.	0.00
13.7500	5.93E-04	314120.	-7691.	-4.91E-04	9164.	1.29E+10	-11.0104	55688.	0.00
14.0000	-7.71E-04	291178.	-7686.	-4.21E-04	8779.	1.29E+10	14.5788	56700.	0.00
14.2500	-0.00193	268340.	-7608.	-3.56E-04	8396.	1.29E+10	37.1767	57713.	0.00
14.5000	-0.00291	245812.	-7467.	-2.96E-04	8019.	1.29E+10	56.8897	58725.	0.00
14.7500	-0.00371	223772.	-7271.	-2.41E-04	7649.	1.29E+10	73.8414	59738.	0.00
15.0000	-0.00435	202377.	-7028.	-1.92E-04	7291.	1.29E+10	88.1696	60750.	0.00
15.2500	-0.00486	181757.	-6746.	-1.47E-04	6945.	1.29E+10	100.0237	61762.	0.00
15.5000	-0.00524	162019.	-6431.	-1.07E-04	6614.	1.29E+10	109.5619	62775.	0.00
15.7500	-0.00550	143253.	-6092.	-7.14E-05	6299.	1.29E+10	116.9489	63788.	0.00
16.0000	-0.00566	125526.	-5733.	-4.01E-05	6002.	1.29E+10	122.3532	64800.	0.00
16.2500	-0.00574	108889.	-5360.	-1.29E-05	5723.	1.29E+10	125.9450	65812.	0.00
16.5000	-0.00574	93374.	-4980.	1.07E-05	5463.	1.29E+10	127.8945	66825.	0.00
16.7500	-0.00568	79003.	-4595.	3.08E-05	5222.	1.29E+10	128.3697	67838.	0.00
17.0000	-0.00556	65779.	-4211.	4.76E-05	5000.	1.29E+10	127.5349	68850.	0.00
17.2500	-0.00539	53697.	-3832.	6.15E-05	4798.	1.29E+10	125.5493	69862.	0.00
17.5000	-0.00519	42740.	-3459.	7.27E-05	4614.	1.29E+10	122.5658	70875.	0.00
17.7500	-0.00495	32882.	-3098.	8.15E-05	4449.	1.29E+10	118.7297	71888.	0.00
18.0000	-0.00470	24090.	-2748.	8.82E-05	4301.	1.29E+10	114.1782	72900.	0.00
18.2500	-0.00443	16322.	-2413.	9.29E-05	4171.	1.29E+10	109.0393	73912.	0.00
18.5000	-0.00414	9535.	-2095.	9.59E-05	4057.	1.29E+10	103.4314	74925.	0.00
18.7500	-0.00385	3678.	-1793.	9.74E-05	3959.	1.29E+10	97.4630	75938.	0.00
19.0000	-0.00356	-1302.	-1510.	9.77E-05	3919.	1.29E+10	91.2323	76950.	0.00
19.2500	-0.00326	-5462.	-1246.	9.69E-05	3989.	1.29E+10	84.8270	77962.	0.00
19.5000	-0.00298	-8857.	-1001.	9.53E-05	4046.	1.29E+10	78.3247	78975.	0.00
19.7500	-0.00269	-11546.	-776.2814	9.29E-05	4091.	1.29E+10	71.7922	79988.	0.00
20.0000	-0.00242	-13589.	-570.6629	9.00E-05	4125.	1.29E+10	65.2868	81000.	0.00
20.2500	-0.00215	-15042.	-384.4496	8.66E-05	4150.	1.29E+10	58.8554	82012.	0.00
20.5000	-0.00190	-15964.	-217.3629	8.30E-05	4165.	1.29E+10	52.5358	83025.	0.00
20.7500	-0.00165	-16413.	-69.0241	7.92E-05	4173.	1.29E+10	46.3567	84037.	0.00
21.0000	-0.00142	-16442.	61.0184	7.54E-05	4173.	1.29E+10	40.3383	85050.	0.00
21.2500	-0.00120	-16107.	173.2647	7.16E-05	4168.	1.29E+10	34.4926	86062.	0.00
21.5000	-9.93E-04	-15459.	268.2407	6.80E-05	4157.	1.29E+10	28.8247	87075.	0.00
21.7500	-7.95E-04	-14551.	346.4766	6.45E-05	4142.	1.29E+10	23.3325	88088.	0.00
22.0000	-6.06E-04	-13432.	408.4879	6.12E-05	4123.	1.29E+10	18.0083	89100.	0.00
22.2500	-4.27E-04	-12149.	454.7583	5.82E-05	4101.	1.29E+10	12.8387	90113.	0.00
22.5000	-2.57E-04	-10750.	485.7255	5.56E-05	4078.	1.29E+10	7.8061	91125.	0.00
22.7500	-9.41E-05	-9279.	501.7682	5.32E-05	4053.	1.29E+10	2.8890	92138.	0.00
23.0000	6.24E-05	-7782.	503.1967	5.12E-05	4028.	1.29E+10	-1.9368	93150.	0.00

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

23.2500	2.13E-04	-6301.	490.2452	4.96E-05	4003.	1.29E+10	-6.6976	94163.	0.00
23.5000	3.60E-04	-4880.	463.0679	4.83E-05	3979.	1.29E+10	-11.4207	95175.	0.00
23.7500	5.03E-04	-3561.	421.7367	4.73E-05	3957.	1.29E+10	-16.1335	96188.	0.00
24.0000	6.44E-04	-2387.	366.2430	4.66E-05	3938.	1.29E+10	-20.8623	97200.	0.00
24.2500	7.83E-04	-1401.	296.5021	4.62E-05	3921.	1.29E+10	-25.6316	98212.	0.00
24.5000	9.21E-04	-645.0738	212.3611	4.59E-05	3908.	1.29E+10	-30.4624	99225.	0.00
24.7500	0.00106	-163.3738	113.6107	4.59E-05	3900.	1.29E+10	-35.3713	100238.	0.00
25.0000	0.00120	0.00	0.00	4.58E-05	3898.	1.29E+10	-40.3692	50625.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection              =     0.35426981 inches
Computed slope at pile head       =       0.000000 radians
Maximum bending moment            =      -1330702. inch-lbs
Maximum shear force               =         21950. lbs
Depth of maximum bending moment   =       0.000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =             12
Number of zero deflection points  =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

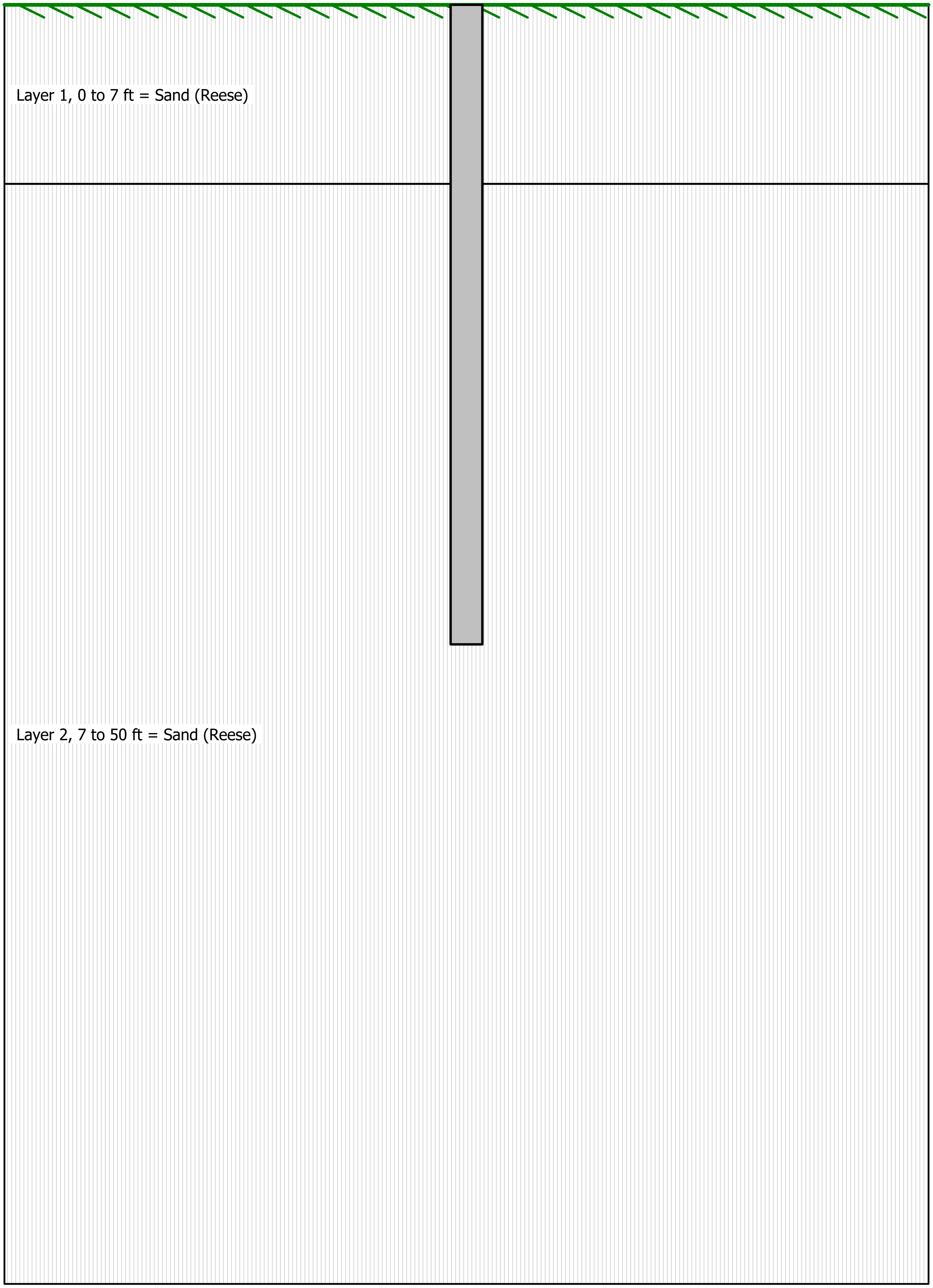
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

1. Parallel to Cap - Br. Abutment (weak axis, HP14x117)

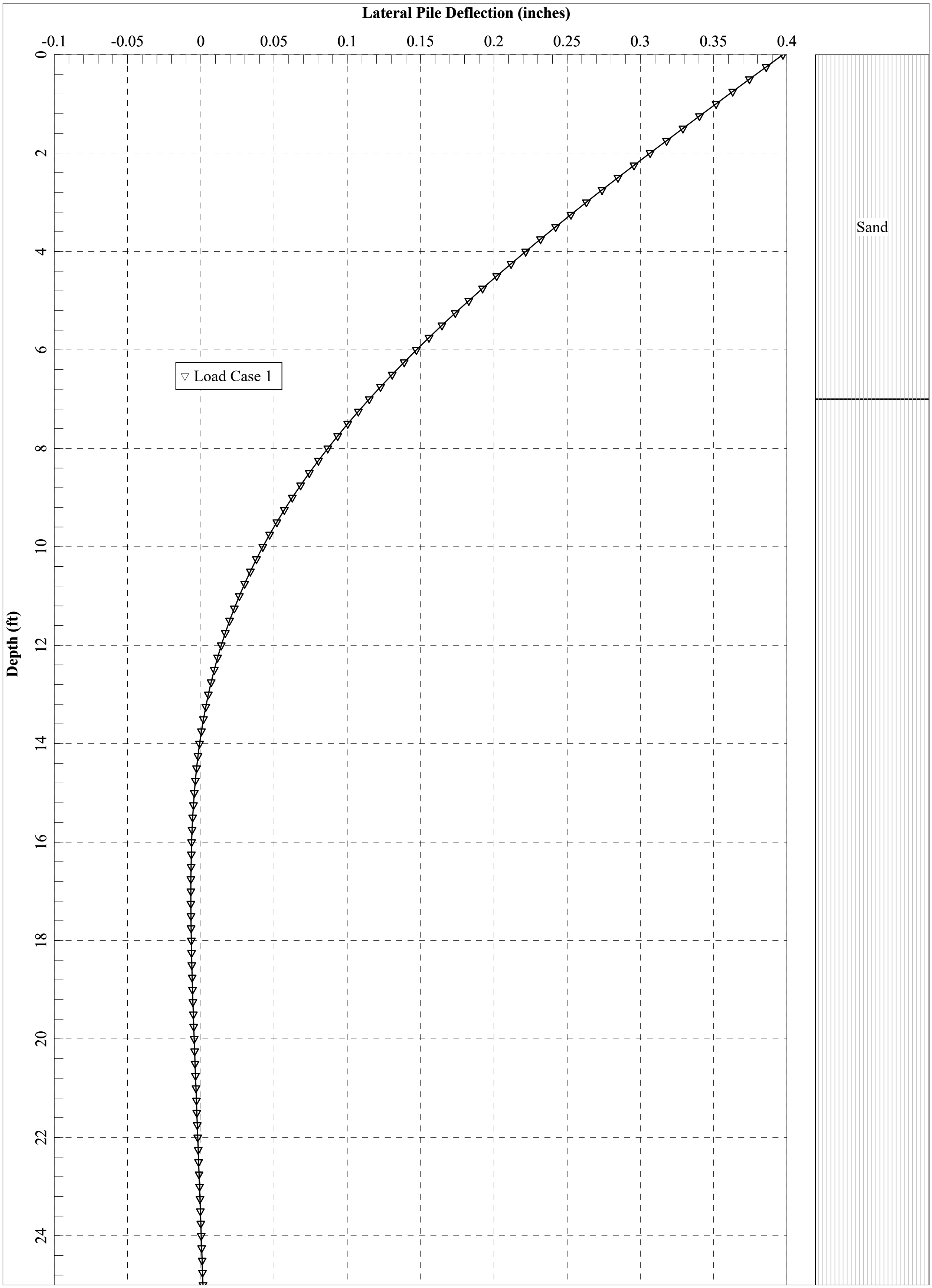
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	21950.	S, rad	0.00	133000.	0.3543	0.00	21950.	-1330702.

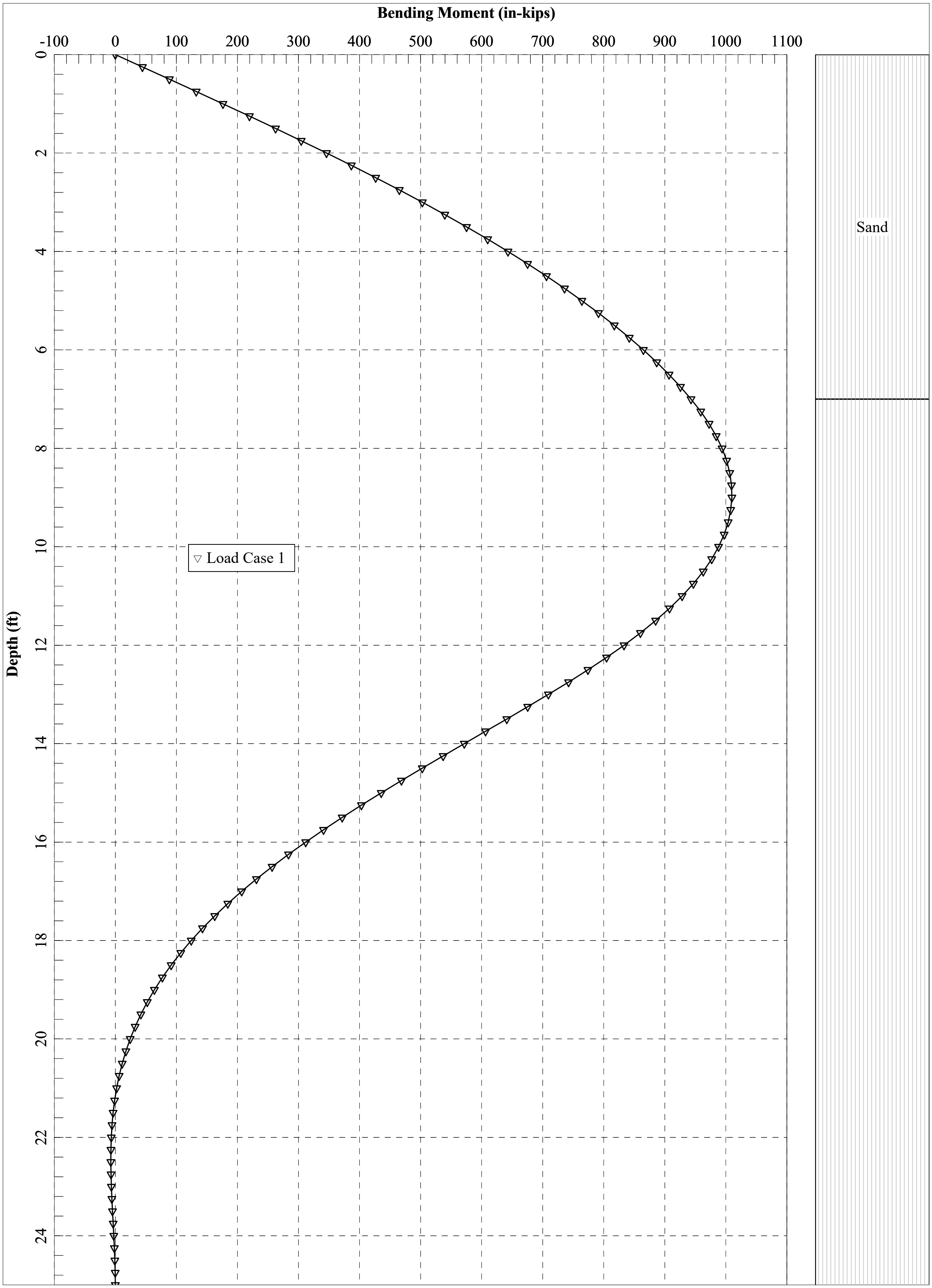
Maximum pile-head deflection = 0.3542698073 inches
Maximum pile-head rotation = -0.0000000000 radians = -0.000000 deg.

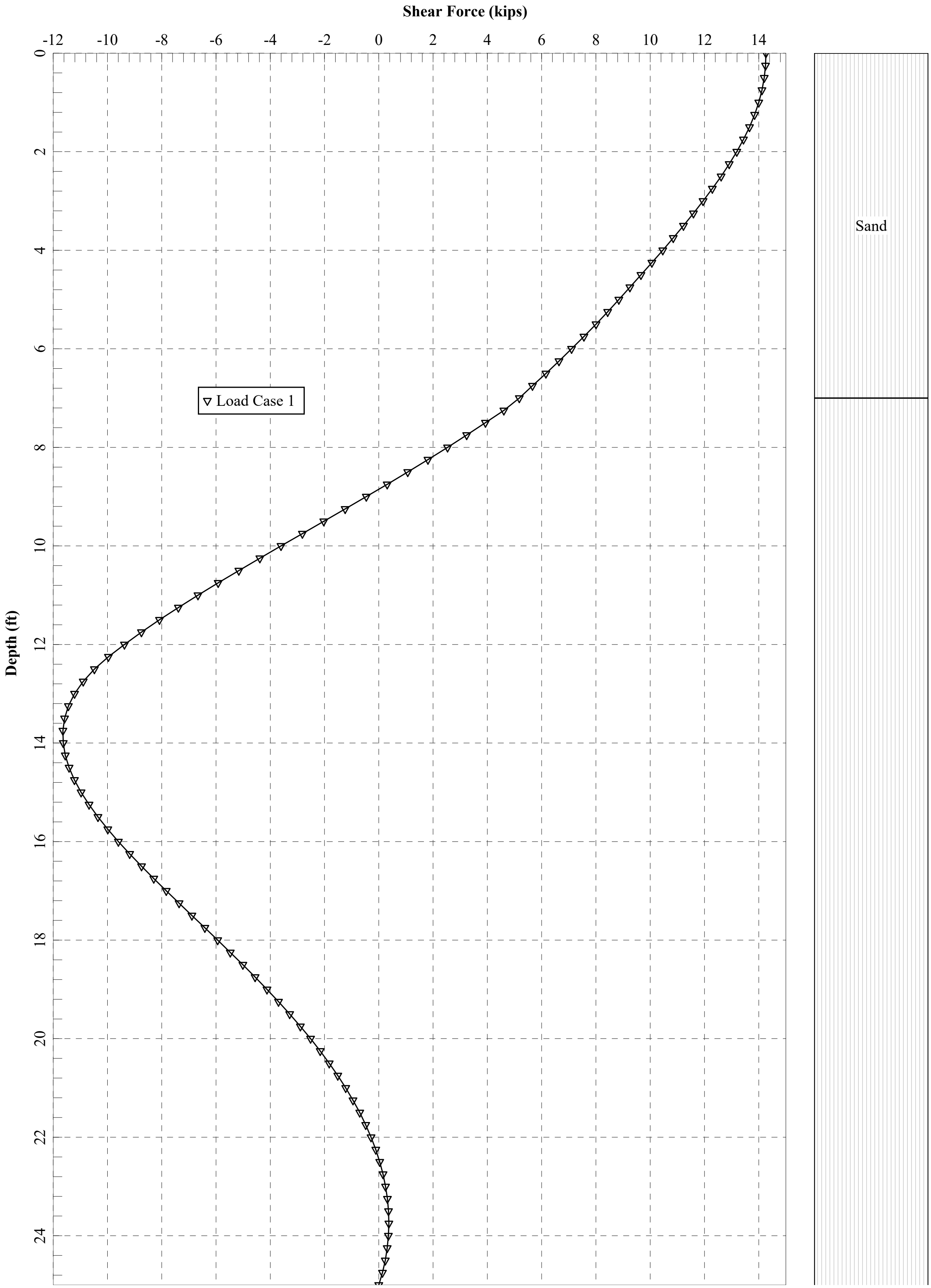
The analysis ended normally.

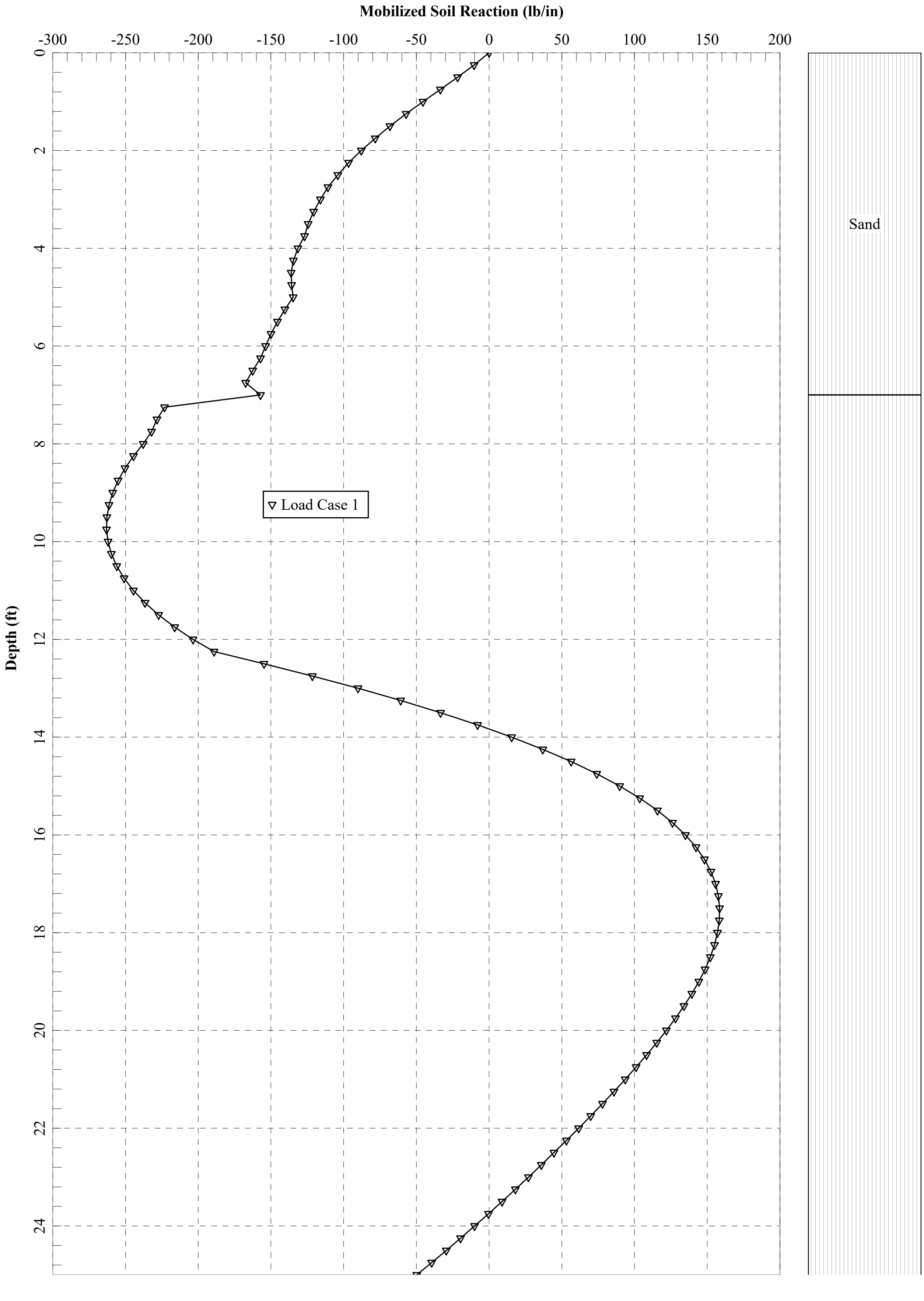


LPile 2018.10.09, © 2018 by Ensoft, Inc.


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand


Bending Moment (in-kips)
-100 0 100 200 300 400 500 600 700 800 900 1000 1100
Depth (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24
Load Case 1
Sand


Shear Force (kips)
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand


Mobilized Soil Reaction (lb/in)
-300
-250
-200
-150
-100
-50
0
50
100
150
200
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Load Case 1
Sand

==

LPile for Windows(Beta), Version 2018-10.009

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

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Files Used for Analysis

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\PIle Length Estimate\LPILE 2019-10-03 and 2019-10-30\

Name of input data file:
2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117).lp10

Name of output report file:
2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117).lp10

Name of plot output file:

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117).lp10

Name of runtime message file:
2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117).lp10

Date and Time of Analysis

Date: November 11, 2019   Time: 10:53:29

Problem Title

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: JRG

Description: HP14x117_Bridge Abutment (perpendicular)

Program Options and Settings

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

```
Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------
```

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

```
Number of pile sections defined                           =           1
Total length of pile                                      =      25.000 ft
Depth of ground surface below top of pile                 =      0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.9000
  2           25.000           14.9000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                      =   25.000000 ft
   Pile width                                             =   14.900000 in
   Shear capacity of section                              =      0.0000 lbs




--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                        =       0.000 degrees
                                                          =       0.000 radians

Pile Batter Angle                                         =       0.000 degrees
                                                          =       0.000 radians
```

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =       0.0000 ft
   Distance from top of pile to bottom of layer        =     7.000000 ft
   Effective unit weight at top of layer               =    62.600000 pcf
   Effective unit weight at bottom of layer            =    62.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =     7.000000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =   125.000000 pci
   Subgrade k at bottom of layer                       =   125.000000 pci


 (Depth of the lowest soil layer extends 25.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
```

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

Layer Num.	Name (p-y Curve Type)	Depth ft	Unit Wt. pcf	Friction deg.	kpy pci
1	Sand	0.00	62.6000	30.0000	60.0000
	(Reese, et al.)	7.0000	62.6000	30.0000	60.0000
2	Sand	7.0000	72.6000	38.0000	125.0000
	(Reese, et al.)	50.0000	72.6000	38.0000	125.0000

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.9000	1.0000
2	25.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

```
-----   ----   --------------------   ----------------------   ---------------   ---------------
   1     1     V =       14265. lbs   M =       0.0000 in-lbs          133000.          No

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Strong Axis:
---------------------------------------------

Length of Section                                           =    25.000000 ft
Flange Width                                                =    14.900000 in
Section Depth                                               =    14.200000 in
Flange Thickness                                            =     0.805000 in
Web Thickness                                               =     0.805000 in
Yield Stress of Pipe                                        =    50.000000 ksi
Elastic Modulus                                             =       29000. ksi
Cross-sectional Area                                        =    34.123950 sq. in.
Moment of Inertia                                           =        1211. in^4
Elastic Bending Stiffness                                   =    35125694. kip-in^2
Plastic Modulus, Z                                          =   192.566083in^3
Plastic Moment Capacity = Fy Z                              =        9628.in-kip
```

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 1706.197 kips
Nominal Axial Tensile Capacity = -1706.197 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	133.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 133.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000469	164.7058821	35100995.	35.7420871	4.8540475	
0.00000938	329.4117641	35100995.	21.4210435	5.8105393	
0.00001408	494.1176462	35100995.	16.6473624	6.7670311	
0.00001877	658.8235283	35100995.	14.2605218	7.7235229	
0.00002346	823.5294104	35100995.	12.8284174	8.6800146	
0.00002815	988.2352924	35100995.	11.8736812	9.6365064	
0.00003285	1153.	35100995.	11.1917267	10.5929981	
0.00003754	1318.	35100995.	10.6802609	11.5494899	
0.00004223	1482.	35100995.	10.2824541	12.5059816	
0.00004692	1647.	35100995.	9.9642087	13.4624734	
0.00005162	1812.	35100995.	9.7038261	14.4189652	
0.00005631	1976.	35100995.	9.4868406	15.3754569	

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

0.00006100	2141.	35100995.	9.3032375	16.3319487	
0.00006569	2306.	35100995.	9.1458634	17.2884404	
0.00007039	2471.	35100995.	9.0094725	18.2449322	
0.00007508	2635.	35100995.	8.8901304	19.2014240	
0.00007977	2800.	35100995.	8.7848287	20.1579157	
0.00008446	2965.	35100995.	8.6912271	21.1144075	
0.00008915	3129.	35100995.	8.6074783	22.0708992	
0.00009385	3294.	35100995.	8.5321044	23.0273910	
0.00009854	3459.	35100995.	8.4639089	23.9838828	
0.0001032	3624.	35100995.	8.4019130	24.9403745	
0.0001079	3788.	35100995.	8.3453081	25.8968663	
0.0001126	3953.	35100995.	8.2934203	26.8533580	
0.0001173	4118.	35100995.	8.2456835	27.8098498	
0.0001220	4282.	35100995.	8.2016187	28.7663415	
0.0001267	4447.	35100995.	8.1608180	29.7228333	
0.0001314	4612.	35100995.	8.1229317	30.6793251	
0.0001361	4776.	35100995.	8.0876582	31.6358168	
0.0001408	4941.	35100995.	8.0547362	32.5923086	
0.0001455	5106.	35100995.	8.0239383	33.5488003	
0.0001502	5271.	35100995.	7.9950652	34.5052921	
0.0001548	5435.	35100995.	7.9679420	35.4617839	
0.0001595	5600.	35100995.	7.9424143	36.4182756	
0.0001642	5765.	35100995.	7.9183453	37.3747674	
0.0001689	5929.	35100995.	7.8956135	38.3312591	
0.0001736	6094.	35100995.	7.8741105	39.2877509	
0.0001783	6259.	35100995.	7.8537391	40.2442427	
0.0001830	6424.	35100995.	7.8344125	41.2007344	
0.0001924	6753.	35100995.	7.7985875	43.1137179	
0.0002018	7082.	35100995.	7.7660950	45.0267015	
0.0002112	7412.	35100995.	7.7364908	46.9396850	
0.0002205	7741.	35100995.	7.7094061	48.8526685	
0.0002299	8058.	35048197.	7.6921227	50.0000000	Y
0.0002393	8306.	34710015.	7.7186576	50.0000000	Y
0.0002487	8454.	33995254.	7.8044658	50.0000000	Y
0.0002581	8553.	33140293.	7.9140327	50.0000000	Y
0.0002675	8644.	32318160.	8.0203646	50.0000000	Y
0.0002768	8729.	31528904.	8.1233718	50.0000000	Y
0.0002862	8808.	30771055.	8.2232002	50.0000000	Y
0.0002956	8881.	30043201.	8.3199845	50.0000000	Y
0.0003050	8947.	29332685.	8.4066431	50.0000000	Y

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

0.0003144	9006.	28644999.	8.4865734	50.0000000	Y
0.0003238	9057.	27974162.	8.5555753	50.0000000	Y
0.0003332	9103.	27322949.	8.6159144	50.0000000	Y
0.0003425	9144.	26694110.	8.6700134	50.0000000	Y
0.0003519	9176.	26075064.	8.7083654	50.0000000	Y
0.0003613	9204.	25473339.	8.7365878	50.0000000	Y
0.0003707	9225.	24885637.	8.7523239	50.0000000	Y
0.0003801	9239.	24308532.	8.7522623	50.0000000	Y
0.0003895	9252.	23756507.	8.7519765	50.0000000	Y
0.0003988	9264.	23227983.	8.7521375	50.0000000	Y
0.0004082	9276.	22722031.	8.7523314	50.0000000	Y
0.0004176	9287.	22237007.	8.7520418	50.0000000	Y
0.0004270	9296.	21771342.	8.7521302	50.0000000	Y
0.0004364	9306.	21324657.	8.7523994	50.0000000	Y
0.0004458	9315.	20895221.	8.7519910	50.0000000	Y
0.0004552	9323.	20482325.	8.7523013	50.0000000	Y
0.0004645	9330.	20085288.	8.7519114	50.0000000	Y
0.0004739	9338.	19702653.	8.7522639	50.0000000	Y
0.0004833	9345.	19334401.	8.7519207	50.0000000	Y
0.0004927	9351.	18979023.	8.7522863	50.0000000	Y
0.0005021	9357.	18636519.	8.7519258	50.0000000	Y
0.0005115	9363.	18305747.	8.7523691	50.0000000	Y
0.0005208	9368.	17986330.	8.7520201	50.0000000	Y
0.0005302	9373.	17677853.	8.7524016	50.0000000	Y
0.0005396	9378.	17379289.	8.7521745	50.0000000	Y
0.0005490	9383.	17090855.	8.7519005	50.0000000	Y
0.0005584	9387.	16811413.	8.7523919	50.0000000	Y
0.0005959	9403.	15778554.	8.7520567	50.0000000	Y
0.0006335	9416.	14864039.	8.7518467	50.0000000	Y
0.0006710	9427.	14048612.	8.7519005	50.0000000	Y
0.0007085	9436.	13317218.	8.7517754	50.0000000	Y
0.0007461	9444.	12657526.	8.7519114	50.0000000	Y
0.0007836	9450.	12059677.	8.7521671	50.0000000	Y
0.0008212	9456.	11515526.	8.7525523	50.0000000	Y
0.0008587	9461.	11018047.	8.7516976	50.0000000	Y
0.0008962	9466.	10561395.	8.7522414	50.0000000	Y
0.0009338	9470.	10141103.	8.7521623	50.0000000	Y
0.0009713	9473.	9752650.	8.7521745	50.0000000	Y

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	133.0000000000	9473.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	18694.
2	7.0000	5.3682	Yes	No	18694.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 14265.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 133000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3973	-2.16E-07	14265.	-0.00381	3898.	3.51E+10	0.00	0.00	0.00
0.2500	0.3859	44317.	14250.	-0.00381	4170.	3.51E+10	-10.2903	80.0014	0.00
0.5000	0.3744	88540.	14202.	-0.00381	4442.	3.51E+10	-21.6120	173.1511	0.00
0.7500	0.3630	132566.	14119.	-0.00380	4713.	3.51E+10	-33.4780	276.6497	0.00
1.0000	0.3517	176285.	14001.	-0.00378	4982.	3.51E+10	-45.4377	387.6274	0.00
1.2500	0.3403	219590.	13847.	-0.00377	5248.	3.51E+10	-57.0428	502.8334	0.00
1.5000	0.3291	262374.	13659.	-0.00375	5511.	3.51E+10	-68.1953	621.7413	0.00
1.7500	0.3178	304535.	13439.	-0.00372	5771.	3.51E+10	-78.3145	739.1754	0.00
2.0000	0.3067	345981.	13190.	-0.00370	6026.	3.51E+10	-87.8245	859.0147	0.00
2.2500	0.2957	386625.	12913.	-0.00366	6276.	3.51E+10	-96.6371	980.5071	0.00
2.5000	0.2847	426385.	12613.	-0.00363	6520.	3.51E+10	-103.9956	1096.	0.00
2.7500	0.2739	465196.	12290.	-0.00359	6759.	3.51E+10	-110.8148	1214.	0.00
3.0000	0.2632	502993.	11950.	-0.00355	6991.	3.51E+10	-115.9582	1322.	0.00
3.2500	0.2526	539729.	11595.	-0.00351	7217.	3.51E+10	-120.5918	1432.	0.00
3.5000	0.2422	575362.	11228.	-0.00346	7436.	3.51E+10	-124.4537	1542.	0.00
3.7500	0.2319	609855.	10851.	-0.00341	7649.	3.51E+10	-126.8346	1641.	0.00
4.0000	0.2217	643185.	10463.	-0.00335	7854.	3.51E+10	-131.4490	1779.	0.00
4.2500	0.2117	675311.	10064.	-0.00330	8051.	3.51E+10	-134.5837	1907.	0.00

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

4.5000	0.2019	706202.	9658.	-0.00324	8241.	3.51E+10	-136.0713	2022.	0.00
4.7500	0.1923	735845.	9251.	-0.00318	8424.	3.51E+10	-135.7554	2118.	0.00
5.0000	0.1829	764240.	8845.	-0.00311	8598.	3.51E+10	-134.7149	2210.	0.00
5.2500	0.1736	791397.	8432.	-0.00305	8765.	3.51E+10	-140.4013	2426.	0.00
5.5000	0.1646	817264.	8003.	-0.00298	8924.	3.51E+10	-145.4969	2652.	0.00
5.7500	0.1558	841793.	7560.	-0.00291	9075.	3.51E+10	-149.9451	2888.	0.00
6.0000	0.1472	864944.	7105.	-0.00283	9218.	3.51E+10	-153.6936	3133.	0.00
6.2500	0.1388	886683.	6638.	-0.00276	9351.	3.51E+10	-157.1728	3398.	0.00
6.5000	0.1306	906976.	6159.	-0.00268	9476.	3.51E+10	-162.4807	3732.	0.00
6.7500	0.1227	925776.	5664.	-0.00260	9592.	3.51E+10	-167.3597	4092.	0.00
7.0000	0.1150	943039.	5177.	-0.00252	9698.	3.51E+10	-157.1801	4100.	0.00
7.2500	0.1076	958854.	4607.	-0.00244	9795.	3.51E+10	-223.1797	6225.	0.00
7.5000	0.1003	972629.	3930.	-0.00236	9880.	3.51E+10	-228.3347	6826.	0.00
7.7500	0.09339	984315.	3239.	-0.00228	9952.	3.51E+10	-232.0532	7454.	0.00
8.0000	0.08669	993879.	2534.	-0.00219	10011.	3.51E+10	-237.7890	8229.	0.00
8.2500	0.08025	1001269.	1811.	-0.00211	10056.	3.51E+10	-244.5085	9141.	0.00
8.5000	0.07406	1006425.	1069.	-0.00202	10088.	3.51E+10	-250.2847	10139.	0.00
8.7500	0.06812	1009293.	310.6089	-0.00193	10105.	3.51E+10	-255.0573	11232.	0.00
9.0000	0.06245	1009832.	-460.1311	-0.00185	10109.	3.51E+10	-258.7693	12431.	0.00
9.2500	0.05704	1008007.	-1240.	-0.00176	10098.	3.51E+10	-261.3678	13747.	0.00
9.5000	0.05188	1003796.	-2027.	-0.00168	10072.	3.51E+10	-262.8030	15196.	0.00
9.7500	0.04698	997185.	-2815.	-0.00159	10031.	3.51E+10	-263.0285	16795.	0.00
10.0000	0.04234	988172.	-3603.	-0.00151	9976.	3.51E+10	-262.0009	18564.	0.00
10.2500	0.03795	976769.	-4385.	-0.00142	9905.	3.51E+10	-259.6788	20527.	0.00
10.5000	0.03381	962994.	-5159.	-0.00134	9821.	3.51E+10	-256.0223	22716.	0.00
10.7500	0.02992	946883.	-5919.	-0.00126	9722.	3.51E+10	-250.9917	25166.	0.00
11.0000	0.02627	928480.	-6663.	-0.00118	9608.	3.51E+10	-244.5455	27926.	0.00
11.2500	0.02286	907845.	-7385.	-0.00110	9482.	3.51E+10	-236.6385	31055.	0.00
11.5000	0.01968	885049.	-8080.	-0.00102	9341.	3.51E+10	-227.2180	34634.	0.00
11.7500	0.01673	860178.	-8745.	-9.47E-04	9188.	3.51E+10	-216.2181	38771.	0.00
12.0000	0.01400	833332.	-9375.	-8.75E-04	9023.	3.51E+10	-203.5520	43620.	0.00
12.2500	0.01148	804626.	-9964.	-8.05E-04	8847.	3.51E+10	-189.0984	49406.	0.00
12.5000	0.00917	774190.	-10480.	-7.37E-04	8659.	3.51E+10	-154.7671	50625.	0.00
12.7500	0.00706	742334.	-10894.	-6.72E-04	8463.	3.51E+10	-121.5036	51638.	0.00
13.0000	0.00514	709360.	-11212.	-6.10E-04	8261.	3.51E+10	-90.1547	52650.	0.00
13.2500	0.00340	675550.	-11438.	-5.51E-04	8053.	3.51E+10	-60.7619	53663.	0.00
13.5000	0.00183	641171.	-11579.	-4.95E-04	7841.	3.51E+10	-33.3513	54675.	0.00
13.7500	4.27E-04	606469.	-11641.	-4.42E-04	7628.	3.51E+10	-7.9346	55688.	0.00
14.0000	-8.20E-04	571675.	-11630.	-3.91E-04	7414.	3.51E+10	15.4897	56700.	0.00
14.2500	-0.00192	537002.	-11551.	-3.44E-04	7201.	3.51E+10	36.9360	57712.	0.00

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

14.5000	-0.00288	502642.	-11411.	-2.99E-04	6989.	3.51E+10	56.4298	58725.	0.00
14.7500	-0.00372	468773.	-11216.	-2.58E-04	6781.	3.51E+10	74.0072	59738.	0.00
15.0000	-0.00443	435554.	-10970.	-2.19E-04	6577.	3.51E+10	89.7135	60750.	0.00
15.2500	-0.00503	403128.	-10680.	-1.83E-04	6377.	3.51E+10	103.6024	61762.	0.00
15.5000	-0.00553	371620.	-10351.	-1.50E-04	6183.	3.51E+10	115.7348	62775.	0.00
15.7500	-0.00593	341141.	-9988.	-1.20E-04	5996.	3.51E+10	126.1777	63788.	0.00
16.0000	-0.00625	311787.	-9596.	-9.20E-05	5815.	3.51E+10	135.0036	64800.	0.00
16.2500	-0.00649	283636.	-9180.	-6.65E-05	5642.	3.51E+10	142.2889	65812.	0.00
16.5000	-0.00665	256757.	-8745.	-4.34E-05	5477.	3.51E+10	148.1135	66825.	0.00
16.7500	-0.00675	231202.	-8294.	-2.26E-05	5320.	3.51E+10	152.5597	67838.	0.00
17.0000	-0.00678	207012.	-7831.	-3.85E-06	5171.	3.51E+10	155.7111	68850.	0.00
17.2500	-0.00677	184216.	-7361.	1.29E-05	5031.	3.51E+10	157.6521	69862.	0.00
17.5000	-0.00671	162833.	-6887.	2.77E-05	4899.	3.51E+10	158.4672	70875.	0.00
17.7500	-0.00660	142870.	-6412.	4.08E-05	4776.	3.51E+10	158.2398	71888.	0.00
18.0000	-0.00646	124327.	-5939.	5.22E-05	4662.	3.51E+10	157.0520	72900.	0.00
18.2500	-0.00629	107193.	-5471.	6.21E-05	4557.	3.51E+10	154.9840	73912.	0.00
18.5000	-0.00609	91451.	-5011.	7.06E-05	4460.	3.51E+10	152.1131	74925.	0.00
18.7500	-0.00587	77074.	-4560.	7.78E-05	4372.	3.51E+10	148.5137	75938.	0.00
19.0000	-0.00562	64031.	-4120.	8.38E-05	4291.	3.51E+10	144.2566	76950.	0.00
19.2500	-0.00536	52284.	-3695.	8.88E-05	4219.	3.51E+10	139.4087	77962.	0.00
19.5000	-0.00509	41791.	-3285.	9.28E-05	4155.	3.51E+10	134.0327	78975.	0.00
19.7500	-0.00481	32502.	-2891.	9.60E-05	4097.	3.51E+10	128.1867	79988.	0.00
20.0000	-0.00452	24365.	-2516.	9.84E-05	4047.	3.51E+10	121.9242	81000.	0.00
20.2500	-0.00422	17325.	-2160.	1.00E-04	4004.	3.51E+10	115.2938	82012.	0.00
20.5000	-0.00391	11323.	-1825.	1.01E-04	3967.	3.51E+10	108.3391	83025.	0.00
20.7500	-0.00361	6294.	-1511.	1.02E-04	3936.	3.51E+10	101.0988	84038.	0.00
21.0000	-0.00330	2176.	-1219.	1.03E-04	3911.	3.51E+10	93.6064	85050.	0.00
21.2500	-0.00299	-1100.	-949.5488	1.03E-04	3904.	3.51E+10	85.8906	86062.	0.00
21.5000	-0.00269	-3603.	-703.7502	1.02E-04	3920.	3.51E+10	77.9752	87075.	0.00
21.7500	-0.00238	-5404.	-481.9684	1.02E-04	3931.	3.51E+10	69.8793	88088.	0.00
22.0000	-0.00207	-6576.	-284.7229	1.01E-04	3938.	3.51E+10	61.6177	89100.	0.00
22.2500	-0.00177	-7194.	-112.4953	1.01E-04	3942.	3.51E+10	53.2007	90112.	0.00
22.5000	-0.00147	-7332.	34.2580	1.00E-04	3943.	3.51E+10	44.6348	91125.	0.00
22.7500	-0.00117	-7068.	155.0948	9.96E-05	3941.	3.51E+10	35.9231	92138.	0.00
23.0000	-8.72E-04	-6481.	249.5771	9.91E-05	3937.	3.51E+10	27.0652	93150.	0.00
23.2500	-5.75E-04	-5650.	317.2624	9.85E-05	3932.	3.51E+10	18.0583	94163.	0.00
23.5000	-2.80E-04	-4656.	357.6961	9.81E-05	3926.	3.51E+10	8.8974	95175.	0.00
23.7500	1.32E-05	-3582.	370.4059	9.77E-05	3920.	3.51E+10	-0.4243	96188.	0.00
24.0000	3.06E-04	-2511.	354.8979	9.75E-05	3913.	3.51E+10	-9.9144	97200.	0.00
24.2500	5.98E-04	-1530.	310.6545	9.73E-05	3907.	3.51E+10	-19.5811	98213.	0.00

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

24.5000	8.90E-04	-725.1122	237.1348	9.72E-05	3902.	3.51E+10	-29.4320	99225.	0.00
24.7500	0.00118	-184.9278	133.7762	9.72E-05	3899.	3.51E+10	-39.4737	100238.	0.00
25.0000	0.00147	0.00	0.00	9.72E-05	3898.	3.51E+10	-49.7105	50625.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.39732491 inches
Computed slope at pile head      =    -0.00381488 radians
Maximum bending moment           =       1009832. inch-lbs
Maximum shear force              =         14265. lbs
Depth of maximum bending moment  =     9.00000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             12
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs

2b. Perp. to Cap - Br. Abutment (strong axis, HP14x117)

1	V, lb	14265.	M, in-lb	0.00	133000.	0.3973	-0.00381	14265.	1009832.

Maximum pile-head deflection = 0.3973249058 inches
Maximum pile-head rotation   = -0.0038148818 radians = -0.218577 deg.

The analysis ended normally.

C2. Pier Pile Analysis

GEI Consultants	Client	HDR Engineering, Inc.			Pg.	
	Project	MassDOT Berkshire Line Bridge 77.16			Rev.	
	By	A. Kormanos	Chk.	W. Lukas	App.	
	Date	3/16/2020	Date	3/18/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 77.16 – Pier Pile Lateral Analyses					

OBJECTIVE

This calculation presents the moment, shear, and mobilized soil reaction from a deflection applied to the top of the pile for the specified pile length for a steel HP14 section at the midspan pier at the Housatonic Railroad, Bridge 77.16, Codding Brook Bridge in Lee, Massachusetts. The applied deflection is the computed deflection from the abutment pile analysis, which is an upper-bound estimate of pile movement.

ANALYTICAL METHODOLOGY

We calculated the applied shear, moment, and mobilized soil reaction for the specified pile lengths at the bridge midspan pier for a steel HP14 section as described below:

1. Developed a soil profile that is representative of the conditions at the midspan pier at Bridge 77.16.
2. Estimated unit weights and strength properties of the soils based on site-specific explorations.
3. Computed the applied vertical loads acting on the pier piles, based on the unfactored vertical loads and revised bridge layout provided by HDR Engineering, Inc. on September 30, 2019.
4. Applied top of pile deflections calculated from the abutment pile analysis to provide a compatible condition between the abutment and pier piles.
5. Prepared four LPILE models to represent a typical pier pile: Loaded parallel to the pile cap for pre and post scour conditions (LPILE Load Case 1a and 1b), and loaded perpendicular to the pile cap, with an analysis for pre and post scour conditions (LPILE Load Case 2a and 2b).
6. Obtained lateral pile-head deflection, bending moment, shear force, and mobilized soil reaction versus depth for each LPILE model.

ELEVATION DATUM

Elevations used in this document are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88).

	Client	HDR Engineering, Inc.			Pg.	
GEI Consultants	Project	MassDOT Berkshire Line Bridge 77.16			Rev.	
	By	A. Kormanos	Chk.	W. Lukas	App.	
	Date	3/16/2020	Date	3/18/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 77.16 – Pier Pile Lateral Analyses					

ASSUMPTIONS

The following assumptions were made for this analysis:

- Groundwater and river elevation, El. 913.
- Ground surface elevation of EL. 908.9 (as measured at B503).
- Fixed-head loading condition at the bridge abutment when loaded parallel to the pile cap.
- Pinned-head loading condition at the bridge abutment when loaded perpendicular to the pile cap.
- The load parallel to the pile cap is applied on the weak axis of the pile section.
- The load perpendicular to the pile cap is applied on the strong axis of the pile section.
- Steel specification for HP14: ASTM A572 Gr 50.
- Pier piles are 35 ft long.
- The deflections in the parallel and perpendicular directions for the abutment piles are the same as the pier piles.

SOIL PROFILE

Soil properties used in this calculation are based on GEI boring B503 performed from October 16 through October 17, 2018 by Aquifer Drilling and Testing, Inc.

A sketch on page 9 presents the general geometry and soil profile used for each LPILE model.

In LPILE, we modeled the pile head at approximately elevation, El. 913.

LPILE SOIL PARAMETERS

Table 1 presents the soil properties used in LPILE. The LPILE soil model and soil modulus parameters were selected based on recommendations in the LPILE Technical Manual (Ensoft 2018).

Table 1. Soil Properties used in LPILE Analyses

Soil Type	LPILE Soil Model	Effective Soil Unit Weight (pcf)	Friction Angle (deg)	Soil Modulus Parameter, k (pci)
Fill / Sand and Gravel	Sand (Reese)	62.6	30	LPILE Default
Silty Sand	Sand (Reese)	67.6	32	LPILE Default
Glacial Till	Sand (Reese)	72.6	38	LPILE Default

Pcf = pounds per cubic foot; pci = pound cubic inch

The pile spacing of the pier piles at the mudline is greater than 5 times the width (B) of the pile. No P-multiplier (group reduction factor) in LPILE was applied based on the 2017 AASHTO LRFD Bridge Design Manual for pile spacing greater than or equal to 5B.

STEEL H-PILES

Based on the soil profile we expect the steel HP14 piles will be driven to refusal in the glacial till or on the top of rock. Due to the potential for pile damage during driving, we recommend using an HP14x117, which is the heaviest HP14 available. While a lighter HP14 may be able to resist the combined axial and flexural loads, the HP14x117 will provide additional stiffness and will improve lateral performance.

DESIGN LOADS

We received the pile loads from HDR Engineering, Inc. in an email on September 30, 2019.

Unfactored - Vertical Load

Load	Abutment	Pier
Dead (kips) (Sub-Structure)	37.21	24.19
Dead (kips) (Super Structure)	60.84	121.68
Live (kips)	200.00	262.20
Impact (kips)	100.62	131.92
Total	398.67	539.98

(Loads provided 09/30/19)

LPILE LOAD CASES

The LPILE analyses considered four load cases:

- Pre-Scour Conditions
  - Loading parallel to the pile cap (Axial = 180 kips , Deflection = 0.35 inches)
  - Loading perpendicular to the pile cap (Axial = 180 kips , Deflection = 0.40 inches)
- Post-Scour Conditions
  - Loading parallel to the pile cap (Axial = 180 kips, Deflection = 0.35 inches)
  - Loading perpendicular to the pile cap (Axial = 180 kips, Deflection = 0.40 inches)

A scour depth of 7.58 feet was used for the post-scour conditions, which is the 100-year flood scour depth at the pier (HDR, 2019).

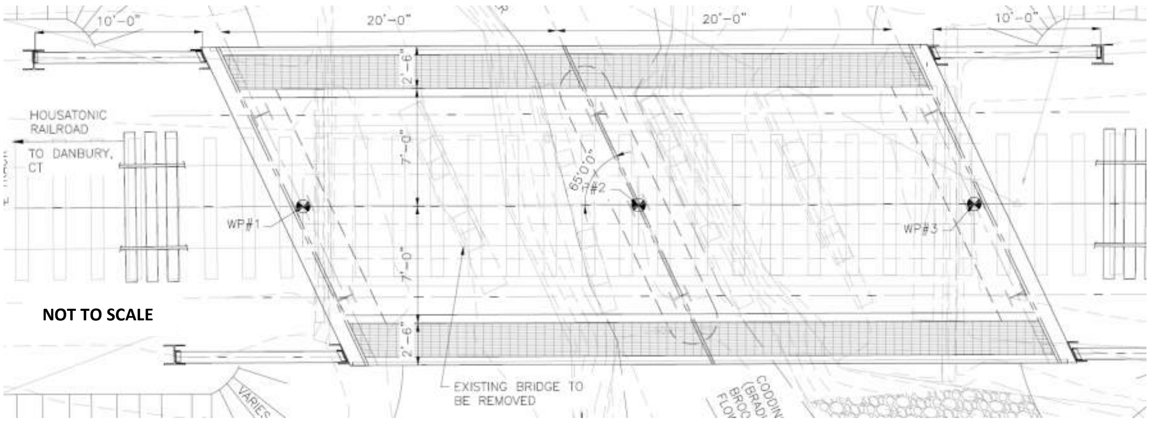


Figure 1. Proposed Bridge Layout Provided by HDR Engineering, Inc.

1. Loading Parallel to the Pile Cap – We applied the same top of pile deflection for an abutment pile loaded parallel to the pile cap applied to the weak axis of a pier pile. We modelled the pile head as fixed against rotation because the pile cap will provide rotation fixity for loading parallel to the pile cap.
2. Perpendicular to the Pile Cap – We applied the same top of pile deflection for an abutment pile loaded perpendicular to the pile cap beam, applied to the strong axis of the pier pile. We modelled the pile head as a pinned connection.

To capture p-delta effects in the LPILE models, we applied an axial load equal to 180 kips per pile for the pier piles.

Table 2. Load Cases

Load Case	Pile Head Condition	Section Axis	Axial Load (kips)	Deflection at Pile Head (in)
1a. Parallel to Pile Cap (Pre-Scour)	Fixed Head	Weak	180	0.35
1b. Parallel to Pile Cap (Post-Scour)	Fixed Head	Weak	180	0.35
2a. Perpendicular to Pile Cap (Pre-Scour)	Pinned Head	Strong	180	0.40
2b. Perpendicular to Pile Cap (Post-Scour)	Pinned Head	Strong	180	0.40

	Client	HDR Engineering, Inc.			Pg.	
	Project	MassDOT Berkshire Line Bridge 77.16			Rev.	
	By	A. Kormanos	Chk.	W. Lukas	App.	
	Date	3/16/2020	Date	3/18/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 77.16 – Pier Pile Lateral Analyses					

RESULTS

The results of these analyses are based on the assumed steel HP14x117 pile section and a pile length of 35 feet. These analyses assume the piles will be advanced a minimum of 16 feet into glacial till (highest allowable tip elevations of approximately El. 878). LPILE computed lateral pile deflection, bending moment, shear force, and mobilized soil reaction versus depth for each soil profile (Attachment: LPILE Outputs).

Table 3. LPILE Results

Load Case	Deflection at Top of Pile (in)	Pile-Head Rotation (rad)	Max Moment (kip-ft)	Max Shear (kips)
1a. Parallel to Pile Cap (Pre-Scour)	0.35	0.00	73.38	10.82
1b. Parallel to Pile Cap (Post-Scour)	0.35	0.00	39.00	3.77
2a. Perpendicular to Pile Cap (Pre-Scour)	0.40	0.00316	59.46	7.20
2b. Perpendicular to Pile Cap (Post-Scour)	0.40	0.00237	38.64	4.80

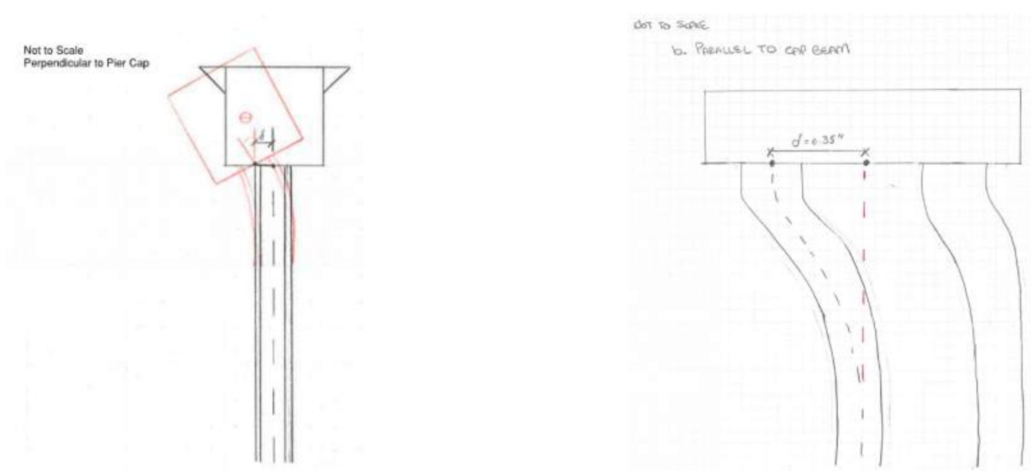


Figure 2. Deflected Pile Shape Subject to: a. Loading Perpendicular to Pile Cap; b. Loading Parallel to Pile Cap

REFERENCES

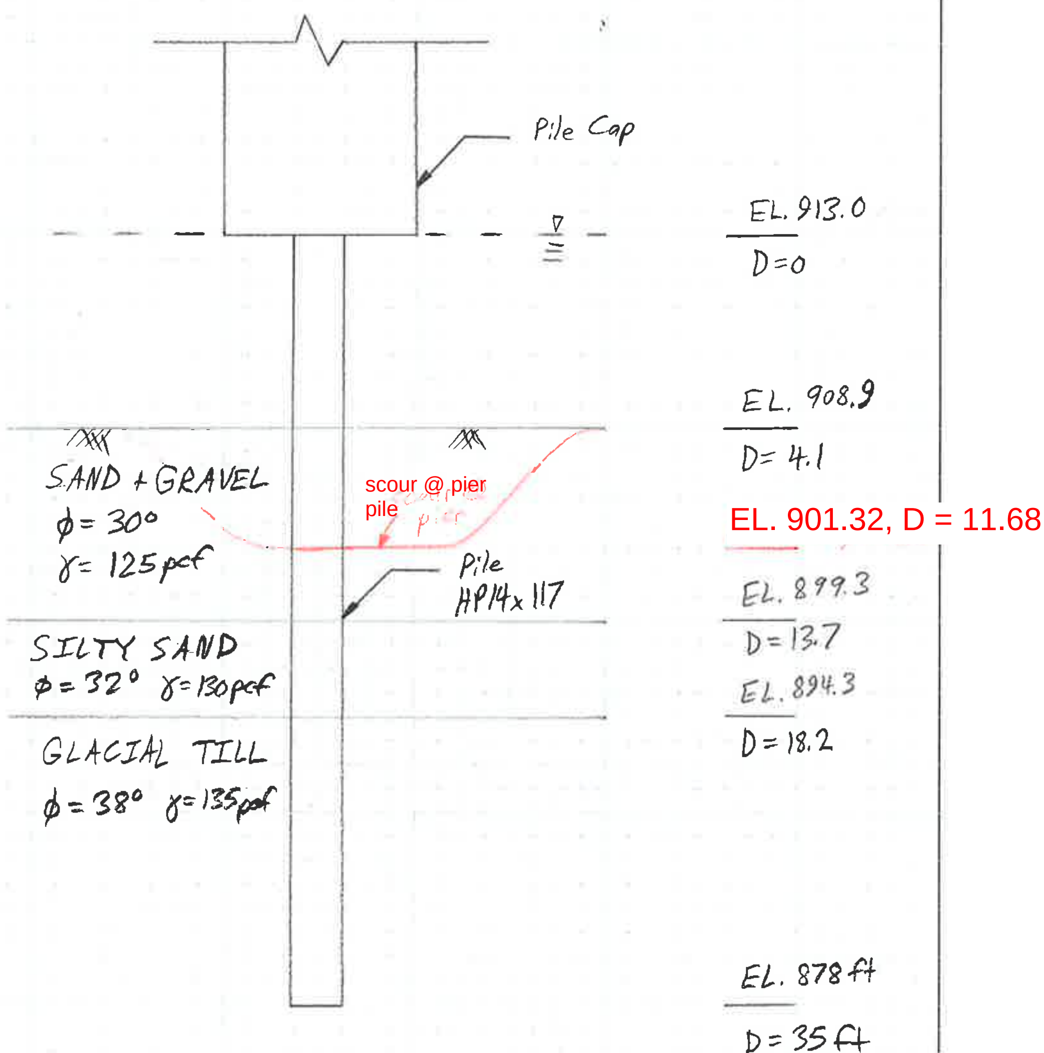
1. AREMA (2016). AREMA Railway Manual, Manual for Railway Engineering.
2. Ensoft, Inc. (2018). Technical Manual for LPILE 2018: A program to Analyze Deep Foundations Under Lateral Loading.
3. Highway Division Massachusetts Department of Transportation (2013). MassDOT LRFD Bridge Manual – Part I Design Guidelines, 2013 Edition.
4. AASHTO (2017). AASHOT LRFD Bridge Design Specifications, 8th Edition
5. HDR (2019). "Determination of Scour at Bridge 77.16, Housatonic River Railroad over Codding Brook," prepared for Massachusetts Department of Transportation – Rail and Transit Division, November 13.

GEI Consultants	Client	HDR Engineering, Inc.			Pg.	
	Project	MassDOT Berkshire Line Bridge 77.16			Rev.	
	By	A. Kormanos	Chk.	W. Lukas	App.	
	Date	3/16/2020	Date	3/18/2020	Date	

Project No.	1703257	Document No.	N/A
Subject	Bridge 77.16 – Pile Analyses		

LPILE OUTPUT

GEI Consultants	Client	HDR			Page	9
	Project	Bridge 77.16			Pg. Rev.	
	By	A. Kormanos	Chk.		App.	
	Date	3/2/2020	Date		Date	
Project No.	1703257	Document No.	N/A			
Subject	Pier Pile Analysis					



Notes:

1. Scour elevation per HDR Hydraulics Report
2. Pile top elevation per 90% drawings.
3. Pile tip elevation per Geotech report
4. Soil profile per B503

```
================================================================================

                  LPile for Windows(Beta), Version 2018-10.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
                           © 1985-2018 by Ensoft, Inc.
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================================================================================

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\Pile Length Estimate\LPILE
2020-02-25_Pier Piles\

Name of input data file:
1a. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Pre Scour.lp10

Name of output report file:
1a. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Pre Scour.lp10

Name of plot output file:
1a. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Pre Scour.lp10

Name of runtime message file:
```

1a. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Pre Scour.lp10

Date and Time of Analysis

Date: March 16, 2020 Time: 10:49:22

Problem Title

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: AHK

Description: HP14x117_Bridge Pier (parallel)_Pre Scour

Program Options and Settings

Computational Options:
 - Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

```
Analysis Control Options:
 - Maximum number of iterations allowed                    =          500
 - Deflection tolerance for convergence                    =   1.0000E-05 in
 - Maximum allowable deflection                            =     100.0000 in
 - Number of pile increments                               =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                            =            1
Total length of pile                                       =       35.000 ft
Depth of ground surface below top of pile                  =       4.1000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.
```

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.9000
2	35.000	14.9000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a H weak axis steel pile
   Length of section                                    =    35.000000 ft
   Pile width                                           =    14.200000 in
   Shear capacity of section                            =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

Pile Batter Angle                                       =        0.000 degrees
                                                        =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer            =     4.100000 ft
   Distance from top of pile to bottom of layer         =    13.700000 ft
   Effective unit weight at top of layer                =    62.600000 pcf
```

```
   Effective unit weight at bottom of layer           =    62.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    13.700000 ft
   Distance from top of pile to bottom of layer       =    18.200000 ft
   Effective unit weight at top of layer              =    67.600000 pcf
   Effective unit weight at bottom of layer           =    67.600000 pcf
   Friction angle at top of layer                     =    32.000000 deg.
   Friction angle at bottom of layer                  =    32.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    18.200000 ft
   Distance from top of pile to bottom of layer       =    50.000000 ft
   Effective unit weight at top of layer              =    72.600000 pcf
   Effective unit weight at bottom of layer           =    72.600000 pcf
   Friction angle at top of layer                     =    38.000000 deg.
   Friction angle at bottom of layer                  =    38.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

 (Depth of the lowest soil layer extends 15.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
```

Layer Num.	Name (p-y Curve Type)	Depth ft	Unit Wt. pcf	Friction deg.	kpy pci
1	Sand	4.1000	62.6000	30.0000	default
	(Reese, et al.)	13.7000	62.6000	30.0000	default
2	Sand	13.7000	67.6000	32.0000	default
	(Reese, et al.)	18.2000	67.6000	32.0000	default
3	Sand	18.2000	72.6000	38.0000	default
	(Reese, et al.)	50.0000	72.6000	38.0000	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.350000 in	S = 0.0000 in/in	180000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

```
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Weak Axis:
---------------------------------------------

Length of Section                                      =    35.000000 ft
Flange Width                                           =    14.900000 in
Section Depth                                          =    14.200000 in
Flange Thickness                                       =     0.805000 in
Web Thickness                                          =     0.805000 in
Yield Stress of Pipe                                   =    50.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    34.123950 sq. in.
Moment of Inertia                                      =   444.363799 in^4
Elastic Bending Stiffness                              =    12886550. kip-in^2
Plastic Modulus, Z                                     =    91.398684in^3
Plastic Moment Capacity = Fy Z                         =        4570.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =     1706.197 kips
Nominal Axial Tensile Capacity                         =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              180.000

Definition of Run Messages:
```

Y = part of pipe section has yielded.

Axial Thrust Force = 180.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000484	62.3688228	12886018.	45.0308331	6.3101210	
0.00000968	124.7376457	12886018.	26.2404166	7.3453544	
0.00001452	187.1064685	12886018.	19.9769444	8.3805878	
0.00001936	249.4752914	12886018.	16.8452083	9.4158212	
0.00002420	311.8441142	12886018.	14.9661666	10.4510546	
0.00002904	374.2129371	12886018.	13.7134722	11.4862880	
0.00003388	436.5817599	12886018.	12.8186904	12.5215214	
0.00003872	498.9505828	12886018.	12.1476041	13.5567548	
0.00004356	561.3194056	12886018.	11.6256481	14.5919882	
0.00004840	623.6882285	12886018.	11.2080833	15.6272216	
0.00005324	686.0570513	12886018.	10.8664394	16.6624550	
0.00005808	748.4258741	12886018.	10.5817361	17.6976884	
0.00006292	810.7946970	12886018.	10.3408333	18.7329219	
0.00006776	873.1635198	12886018.	10.1343452	19.7681553	
0.00007260	935.5323427	12886018.	9.9553889	20.8033887	
0.00007744	997.9011655	12886018.	9.7988021	21.8386221	
0.00008228	1060.	12886018.	9.6606372	22.8738555	
0.00008712	1123.	12886018.	9.5378241	23.9090889	
0.00009196	1185.	12886018.	9.4279386	24.9443223	
0.00009680	1247.	12886018.	9.3290417	25.9795557	
0.0001016	1310.	12886018.	9.2395635	27.0147891	
0.0001065	1372.	12886018.	9.1582197	28.0500225	
0.0001113	1434.	12886018.	9.0839493	29.0852559	
0.0001162	1497.	12886018.	9.0158680	30.1204893	
0.0001210	1559.	12886018.	8.9532333	31.1557227	
0.0001258	1622.	12886018.	8.8954167	32.1909561	
0.0001307	1684.	12886018.	8.8418827	33.2261895	
0.0001355	1746.	12886018.	8.7921726	34.2614229	
0.0001404	1809.	12886018.	8.7458908	35.2966564	
0.0001452	1871.	12886018.	8.7026944	36.3318898	
0.0001500	1933.	12886018.	8.6622849	37.3671232	
0.0001549	1996.	12886018.	8.6244010	38.4023566	
0.0001597	2058.	12886018.	8.5888131	39.4375900	
0.0001646	2121.	12886018.	8.5553186	40.4728234	

0.0001694	2183.	12886018.	8.5237381	41.5080568	
0.0001742	2245.	12886018.	8.4939120	42.5432902	
0.0001791	2308.	12886018.	8.4656982	43.5785236	
0.0001839	2370.	12886018.	8.4389693	44.6137570	
0.0001888	2432.	12886018.	8.4136111	45.6489904	
0.0001984	2557.	12886018.	8.3666057	47.7194572	
0.0002081	2682.	12886018.	8.3239729	49.7899240	Y
0.0002178	2802.	12863270.	8.2882675	50.0000000	Y
0.0002275	2914.	12808474.	8.2604432	50.0000000	Y
0.0002372	3019.	12730671.	8.2389823	50.0000000	Y
0.0002468	3119.	12634556.	8.2229969	50.0000000	Y
0.0002565	3213.	12525649.	8.2114635	50.0000000	Y
0.0002662	3301.	12401279.	8.2024140	50.0000000	Y
0.0002759	3380.	12250582.	8.1935402	50.0000000	Y
0.0002856	3451.	12085228.	8.1849244	50.0000000	Y
0.0002952	3515.	11905763.	8.1764040	50.0000000	Y
0.0003049	3573.	11718902.	8.1682397	50.0000000	Y
0.0003146	3627.	11527414.	8.1602859	50.0000000	Y
0.0003243	3675.	11332602.	8.1523745	50.0000000	Y
0.0003340	3719.	11136787.	8.1446263	50.0000000	Y
0.0003436	3760.	10941551.	8.1370719	50.0000000	Y
0.0003533	3798.	10747977.	8.1296820	50.0000000	Y
0.0003630	3832.	10556967.	8.1224296	50.0000000	Y
0.0003727	3864.	10368817.	8.1153886	50.0000000	Y
0.0003824	3894.	10183089.	8.1084756	50.0000000	Y
0.0003920	3921.	10001546.	8.1016327	50.0000000	Y
0.0004017	3947.	9824626.	8.0948386	50.0000000	Y
0.0004114	3971.	9651298.	8.0885953	50.0000000	Y
0.0004211	3993.	9482079.	8.0821223	50.0000000	Y
0.0004308	4014.	9317199.	8.0757683	50.0000000	Y
0.0004404	4033.	9156826.	8.0698601	50.0000000	Y
0.0004501	4051.	9000406.	8.0636014	50.0000000	Y
0.0004598	4068.	8847985.	8.0578580	50.0000000	Y
0.0004695	4085.	8700220.	8.0519854	50.0000000	Y
0.0004792	4100.	8555772.	8.0463580	50.0000000	Y
0.0004888	4114.	8415953.	8.0408260	50.0000000	Y
0.0004985	4127.	8279427.	8.0352710	50.0000000	Y
0.0005082	4140.	8146928.	8.0300405	50.0000000	Y
0.0005179	4153.	8018210.	8.0245187	50.0000000	Y
0.0005276	4164.	7892476.	8.0195560	50.0000000	Y
0.0005372	4175.	7770646.	8.0144730	50.0000000	Y
0.0005469	4185.	7651935.	8.0093068	50.0000000	Y
0.0005566	4195.	7536626.	8.0047470	50.0000000	Y

0.0005663	4204.	7423949.	7.9996764	50.0000000	Y
0.0005760	4213.	7314831.	7.9948737	50.0000000	Y
0.0006147	4245.	6905354.	7.9768768	50.0000000	Y
0.0006534	4271.	6536288.	7.9597874	50.0000000	Y
0.0006921	4293.	6202837.	7.9437685	50.0000000	Y
0.0007308	4312.	5900172.	7.9288273	50.0000000	Y
0.0007696	4328.	5624461.	7.9149109	50.0000000	Y
0.0008083	4343.	5372811.	7.9016602	50.0000000	Y
0.0008470	4355.	5141927.	7.8891577	50.0000000	Y
0.0008857	4366.	4929338.	7.8771842	50.0000000	Y
0.0009244	4376.	4733544.	7.8660074	50.0000000	Y
0.0009632	4385.	4552268.	7.8553076	50.0000000	Y
0.0010019	4392.	4384047.	7.8452320	50.0000000	Y
0.0010406	4400.	4227890.	7.8354115	50.0000000	Y
0.0010793	4406.	4082001.	7.8264157	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	180.0000000000	4406.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	4.1000	0.00	N.A.	No	0.00	41621.
2	13.7000	9.0386	Yes	No	41621.	84687.
3	18.2000	11.2840	Yes	No	126308.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.350000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 180000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3500	-880532.	10819.	0.00	20037.	1.29E+10	0.00	0.00	0.00
0.3500	0.3494	-834989.	10818.	-2.80E-04	19274.	1.29E+10	0.00	0.00	0.00
0.7000	0.3477	-789240.	10818.	-5.44E-04	18507.	1.29E+10	0.00	0.00	0.00
1.0500	0.3448	-743297.	10818.	-7.94E-04	17737.	1.29E+10	0.00	0.00	0.00
1.4000	0.3410	-697171.	10818.	-0.00103	16963.	1.29E+10	0.00	0.00	0.00
1.7500	0.3362	-650872.	10818.	-0.00125	16187.	1.29E+10	0.00	0.00	0.00
2.1000	0.3305	-604414.	10818.	-0.00145	15408.	1.29E+10	0.00	0.00	0.00

2.4500	0.3240	-557806.	10818.	-0.00164	14627.	1.29E+10	0.00	0.00	0.00
2.8000	0.3167	-511062.	10818.	-0.00182	13843.	1.29E+10	0.00	0.00	0.00
3.1500	0.3087	-464191.	10818.	-0.00198	13057.	1.29E+10	0.00	0.00	0.00
3.5000	0.3001	-417206.	10818.	-0.00212	12270.	1.29E+10	0.00	0.00	0.00
3.8500	0.2909	-370118.	10818.	-0.00225	11480.	1.29E+10	0.00	0.00	0.00
4.2000	0.2812	-322938.	10809.	-0.00236	10689.	1.29E+10	-3.9510	59.0063	0.00
4.5500	0.2711	-275749.	10761.	-0.00246	9898.	1.29E+10	-19.2299	297.9291	0.00
4.9000	0.2606	-228831.	10645.	-0.00254	9111.	1.29E+10	-35.7768	576.6535	0.00
5.2500	0.2498	-182488.	10460.	-0.00261	8334.	1.29E+10	-52.4050	881.2800	0.00
5.6000	0.2387	-137025.	10207.	-0.00266	7572.	1.29E+10	-68.2064	1200.	0.00
5.9500	0.2274	-92731.	9891.	-0.00270	6830.	1.29E+10	-82.0337	1515.	0.00
6.3000	0.2160	-49861.	9520.	-0.00272	6111.	1.29E+10	-94.9410	1846.	0.00
6.6500	0.2046	-8653.	9099.	-0.00273	5420.	1.29E+10	-105.1876	2160.	0.00
7.0000	0.1931	30701.	8640.	-0.00273	5790.	1.29E+10	-113.5058	2469.	0.00
7.3500	0.1817	68046.	8151.	-0.00271	6416.	1.29E+10	-119.2165	2756.	0.00
7.7000	0.1703	103270.	7643.	-0.00268	7006.	1.29E+10	-122.6633	3025.	0.00
8.0500	0.1591	136305.	7121.	-0.00264	7560.	1.29E+10	-125.9052	3323.	0.00
8.4000	0.1481	167086.	6588.	-0.00259	8076.	1.29E+10	-127.8967	3626.	0.00
8.7500	0.1374	195570.	6055.	-0.00253	8554.	1.29E+10	-126.2453	3860.	0.00
9.1000	0.1268	221778.	5534.	-0.00247	8993.	1.29E+10	-121.9651	4039.	0.00
9.4500	0.1166	245781.	5009.	-0.00239	9396.	1.29E+10	-127.5961	4595.	0.00
9.8000	0.1068	267471.	4465.	-0.00231	9759.	1.29E+10	-131.8577	5187.	0.00
10.1500	0.09726	286771.	3905.	-0.00222	10083.	1.29E+10	-134.6295	5814.	0.00
10.5000	0.08815	303624.	3332.	-0.00212	10365.	1.29E+10	-138.2560	6587.	0.00
10.8500	0.07945	317964.	2742.	-0.00202	10606.	1.29E+10	-142.7855	7548.	0.00
11.2000	0.07119	329707.	2135.	-0.00191	10803.	1.29E+10	-146.2892	8630.	0.00
11.5500	0.06338	338788.	1515.	-0.00180	10955.	1.29E+10	-148.6993	9853.	0.00
11.9000	0.05604	345162.	888.0026	-0.00169	11062.	1.29E+10	-149.9580	11239.	0.00
12.2500	0.04916	348806.	258.0539	-0.00158	11123.	1.29E+10	-150.0176	12816.	0.00
12.6000	0.04277	349718.	-369.5482	-0.00147	11138.	1.29E+10	-148.8405	14617.	0.00
12.9500	0.03685	347918.	-966.0204	-0.00135	11108.	1.29E+10	-135.1939	15408.	0.00
13.3000	0.03141	343648.	-1501.	-0.00124	11036.	1.29E+10	-119.7909	16018.	0.00
13.6500	0.02644	337180.	-1973.	-0.00113	10928.	1.29E+10	-104.6716	16627.	0.00
14.0000	0.02193	328782.	-2485.	-0.00102	10787.	1.29E+10	-139.3864	26694.	0.00
14.3500	0.01787	317845.	-3030.	-9.15E-04	10604.	1.29E+10	-120.0899	28221.	0.00
14.7000	0.01425	304711.	-3490.	-8.13E-04	10384.	1.29E+10	-99.0118	29184.	0.00
15.0500	0.01104	289755.	-3865.	-7.16E-04	10133.	1.29E+10	-79.2651	30148.	0.00
15.4000	0.00823	273329.	-4159.	-6.24E-04	9857.	1.29E+10	-60.9854	31112.	0.00
15.7500	0.00580	255761.	-4380.	-5.38E-04	9563.	1.29E+10	-44.2738	32075.	0.00
16.1000	0.00371	237348.	-4535.	-4.58E-04	9254.	1.29E+10	-29.1988	33039.	0.00
16.4500	0.00195	218362.	-4629.	-3.84E-04	8936.	1.29E+10	-15.7972	34003.	0.00
16.8000	4.90E-04	199044.	-4671.	-3.16E-04	8612.	1.29E+10	-4.0764	34966.	0.00
17.1500	-7.00E-04	179604.	-4667.	-2.54E-04	8286.	1.29E+10	5.9841	35930.	0.00

17.5000	-0.00164	160226.	-4624.	-1.98E-04	7961.	1.29E+10	14.4306	36894.	0.00
17.8500	-0.00237	141063.	-4549.	-1.49E-04	7640.	1.29E+10	21.3329	37857.	0.00
18.2000	-0.00290	122241.	-4381.	-1.06E-04	7324.	1.29E+10	58.8480	85299.	0.00
18.5500	-0.00326	104427.	-4114.	-6.95E-05	7026.	1.29E+10	67.8746	87416.	0.00
18.9000	-0.00348	87785.	-3816.	-3.82E-05	6747.	1.29E+10	74.2203	89534.	0.00
19.2500	-0.00358	72431.	-3496.	-1.21E-05	6489.	1.29E+10	78.1660	91651.	0.00
19.6000	-0.00358	58437.	-3164.	9.23E-06	6255.	1.29E+10	79.9992	93768.	0.00
19.9500	-0.00350	45841.	-2828.	2.62E-05	6043.	1.29E+10	80.0074	95886.	0.00
20.3000	-0.00336	34644.	-2495.	3.93E-05	5856.	1.29E+10	78.4719	98003.	0.00
20.6500	-0.00317	24823.	-2171.	4.90E-05	5691.	1.29E+10	75.6632	100120.	0.00
21.0000	-0.00295	16331.	-1862.	5.57E-05	5549.	1.29E+10	71.8368	102238.	0.00
21.3500	-0.00271	9102.	-1570.	5.99E-05	5427.	1.29E+10	67.2301	104355.	0.00
21.7000	-0.00245	3056.	-1298.	6.19E-05	5326.	1.29E+10	62.0603	106473.	0.00
22.0500	-0.00219	-1895.	-1049.	6.21E-05	5307.	1.29E+10	56.5225	108590.	0.00
22.4000	-0.00193	-5849.	-823.6490	6.08E-05	5373.	1.29E+10	50.7889	110707.	0.00
22.7500	-0.00168	-8906.	-622.4733	5.84E-05	5424.	1.29E+10	45.0090	112825.	0.00
23.1000	-0.00144	-11166.	-445.4047	5.51E-05	5462.	1.29E+10	39.3094	114942.	0.00
23.4500	-0.00121	-12731.	-291.8863	5.12E-05	5488.	1.29E+10	33.7946	117059.	0.00
23.8000	-0.00101	-13696.	-160.9652	4.69E-05	5505.	1.29E+10	28.5487	119177.	0.00
24.1500	-8.18E-04	-14154.	-51.3770	4.24E-05	5512.	1.29E+10	23.6361	121294.	0.00
24.5000	-6.50E-04	-14191.	38.3764	3.78E-05	5513.	1.29E+10	19.1036	123411.	0.00
24.8500	-5.01E-04	-13888.	109.9564	3.32E-05	5508.	1.29E+10	14.9821	125529.	0.00
25.2000	-3.71E-04	-13318.	165.1240	2.87E-05	5498.	1.29E+10	11.2882	127646.	0.00
25.5500	-2.60E-04	-12545.	205.6854	2.45E-05	5485.	1.29E+10	8.0267	129763.	0.00
25.9000	-1.65E-04	-11627.	233.4446	2.06E-05	5470.	1.29E+10	5.1919	131881.	0.00
26.2500	-8.68E-05	-10615.	250.1640	1.70E-05	5453.	1.29E+10	2.7697	133998.	0.00
26.6000	-2.28E-05	-9551.	257.5327	1.37E-05	5435.	1.29E+10	0.7392	136115.	0.00
26.9500	2.81E-05	-8472.	257.1416	1.07E-05	5417.	1.29E+10	-0.9254	138233.	0.00
27.3000	6.74E-05	-7408.	250.4651	8.16E-06	5399.	1.29E+10	-2.2539	140350.	0.00
27.6500	9.66E-05	-6381.	238.8481	5.91E-06	5382.	1.29E+10	-3.2780	142468.	0.00
28.0000	1.17E-04	-5410.	223.4995	3.99E-06	5366.	1.29E+10	-4.0309	144585.	0.00
28.3500	1.30E-04	-4510.	205.4889	2.37E-06	5350.	1.29E+10	-4.5456	146702.	0.00
28.7000	1.37E-04	-3688.	185.7479	1.04E-06	5337.	1.29E+10	-4.8548	148820.	0.00
29.0500	1.39E-04	-2951.	165.0748	-4.61E-08	5324.	1.29E+10	-4.9895	150937.	0.00
29.4000	1.37E-04	-2301.	144.1412	-9.02E-07	5313.	1.29E+10	-4.9789	153054.	0.00
29.7500	1.31E-04	-1739.	123.5015	-1.56E-06	5304.	1.29E+10	-4.8496	155172.	0.00
30.1000	1.24E-04	-1261.	103.6033	-2.05E-06	5296.	1.29E+10	-4.6258	157289.	0.00
30.4500	1.14E-04	-865.2982	84.7991	-2.40E-06	5289.	1.29E+10	-4.3286	159406.	0.00
30.8000	1.03E-04	-545.4025	67.3587	-2.63E-06	5284.	1.29E+10	-3.9763	161524.	0.00
31.1500	9.20E-05	-295.5152	51.4814	-2.76E-06	5280.	1.29E+10	-3.5843	163641.	0.00
31.5000	8.02E-05	-108.7814	37.3086	-2.83E-06	5277.	1.29E+10	-3.1647	165758.	0.00
31.8500	6.82E-05	22.1538	24.9354	-2.84E-06	5275.	1.29E+10	-2.7273	167876.	0.00
32.2000	5.63E-05	104.9741	14.4221	-2.82E-06	5277.	1.29E+10	-2.2791	169993.	0.00

32.5500	4.45E-05	147.5660	5.8042	-2.78E-06	5277.	1.29E+10	-1.8247	172110.	0.00
32.9000	3.29E-05	157.9339	-0.8980	-2.73E-06	5278.	1.29E+10	-1.3668	174228.	0.00
33.2500	2.16E-05	144.1523	-5.6717	-2.68E-06	5277.	1.29E+10	-0.9064	176345.	0.00
33.6000	1.04E-05	114.3470	-8.5049	-2.64E-06	5277.	1.29E+10	-0.4428	178463.	0.00
33.9500	-5.87E-07	76.7022	-9.3818	-2.61E-06	5276.	1.29E+10	0.02524	180580.	0.00
34.3000	-1.15E-05	39.4838	-8.2792	-2.59E-06	5276.	1.29E+10	0.4998	182697.	0.00
34.6500	-2.23E-05	11.0728	-5.1651	-2.58E-06	5275.	1.29E+10	0.9830	184815.	0.00
35.0000	-3.32E-05	0.00	0.00	-2.58E-06	5275.	1.29E+10	1.4765	93466.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.35000000 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =       -880532. inch-lbs
Maximum shear force              =         10819. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              3
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

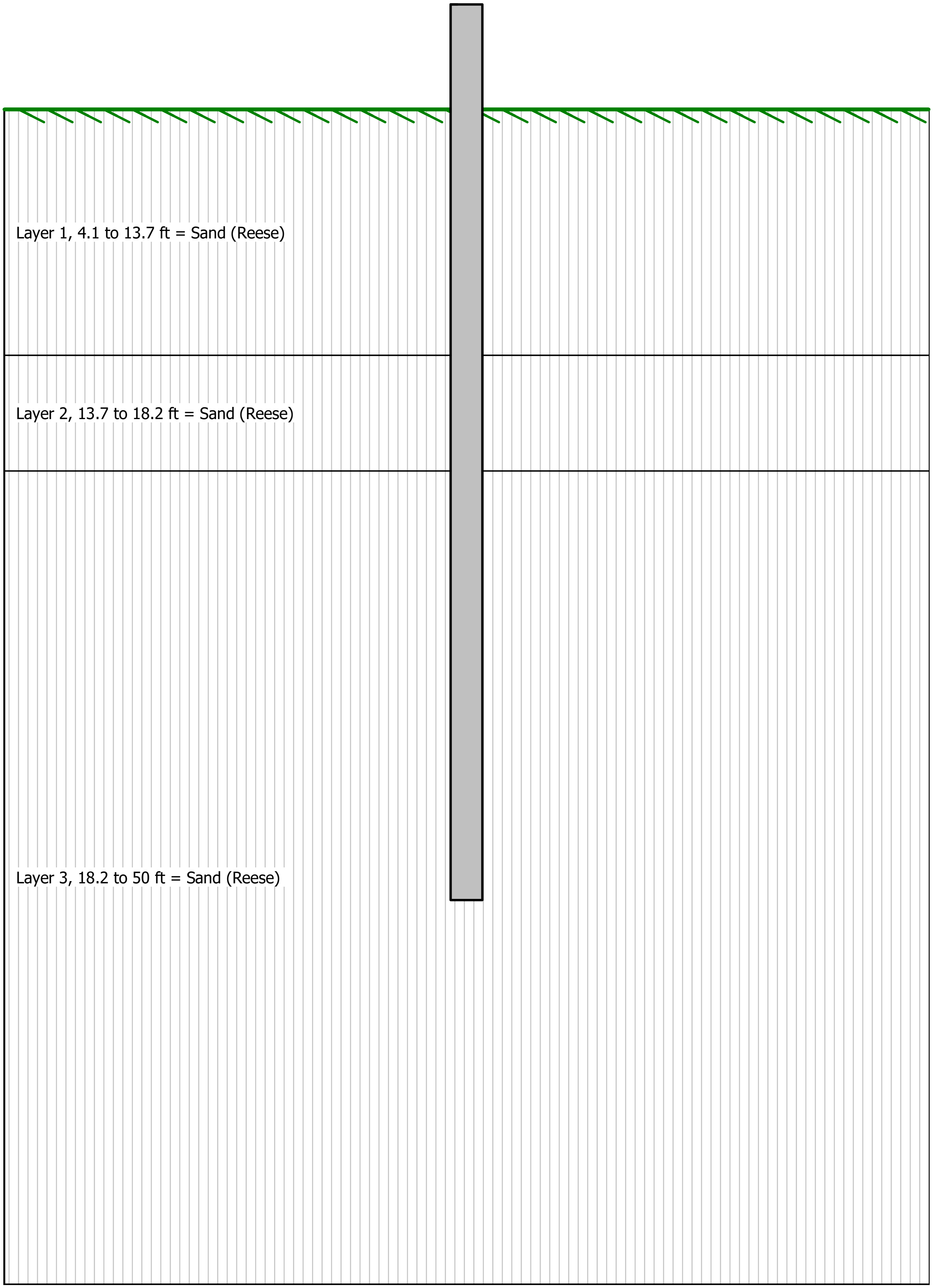
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Load Load Axial Pile-head Pile-head Max Shear Max Moment

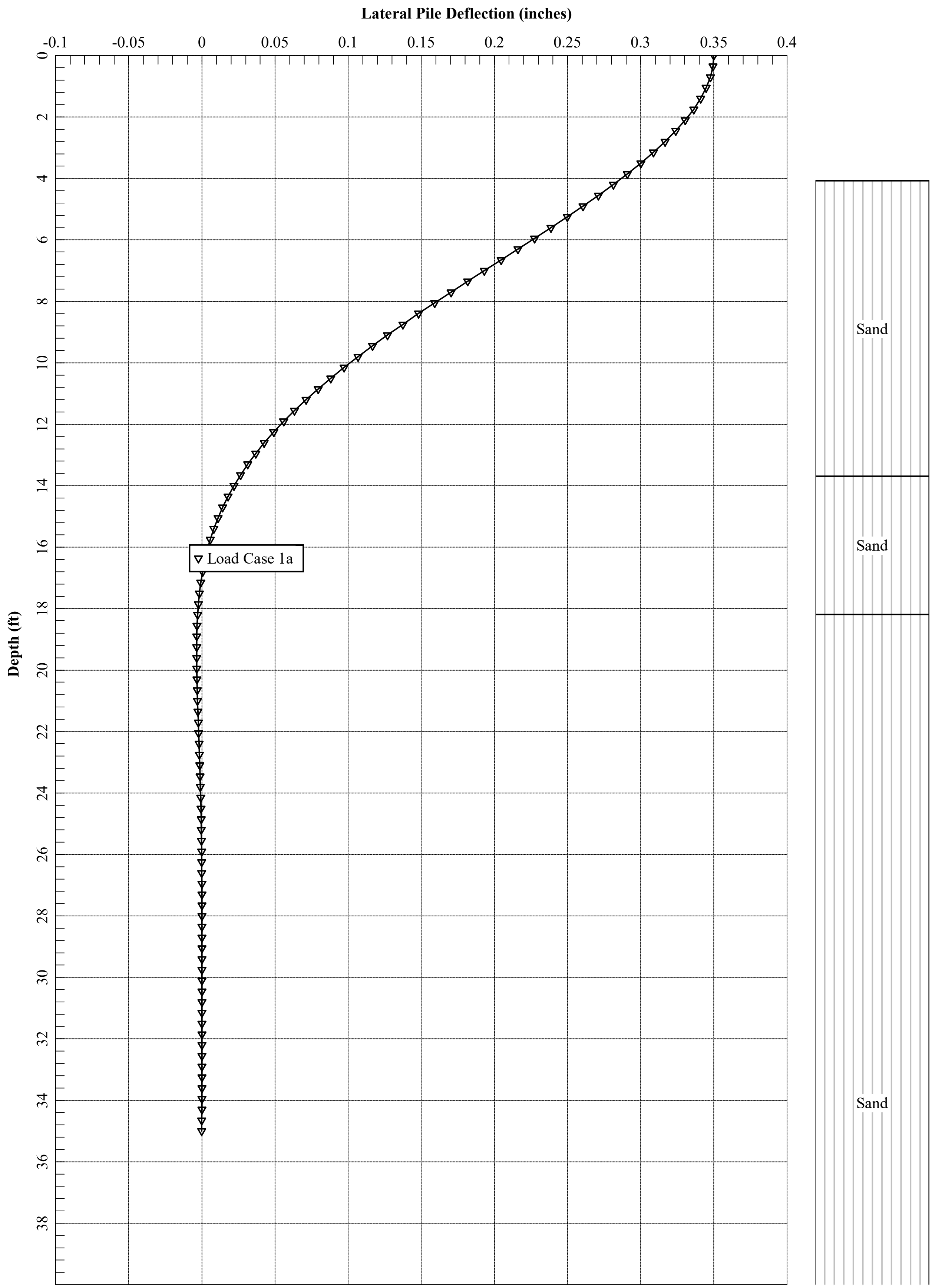
Case No.	Type 1	Pile-head Load 1	Type 2	Pile-head Load 2	Loading lbs	Deflection inches	Rotation radians	in Pile lbs	in Pile in-lbs
1	y, in	0.3500	S, rad	0.00	180000.	0.3500	0.00	10819.	-880532.

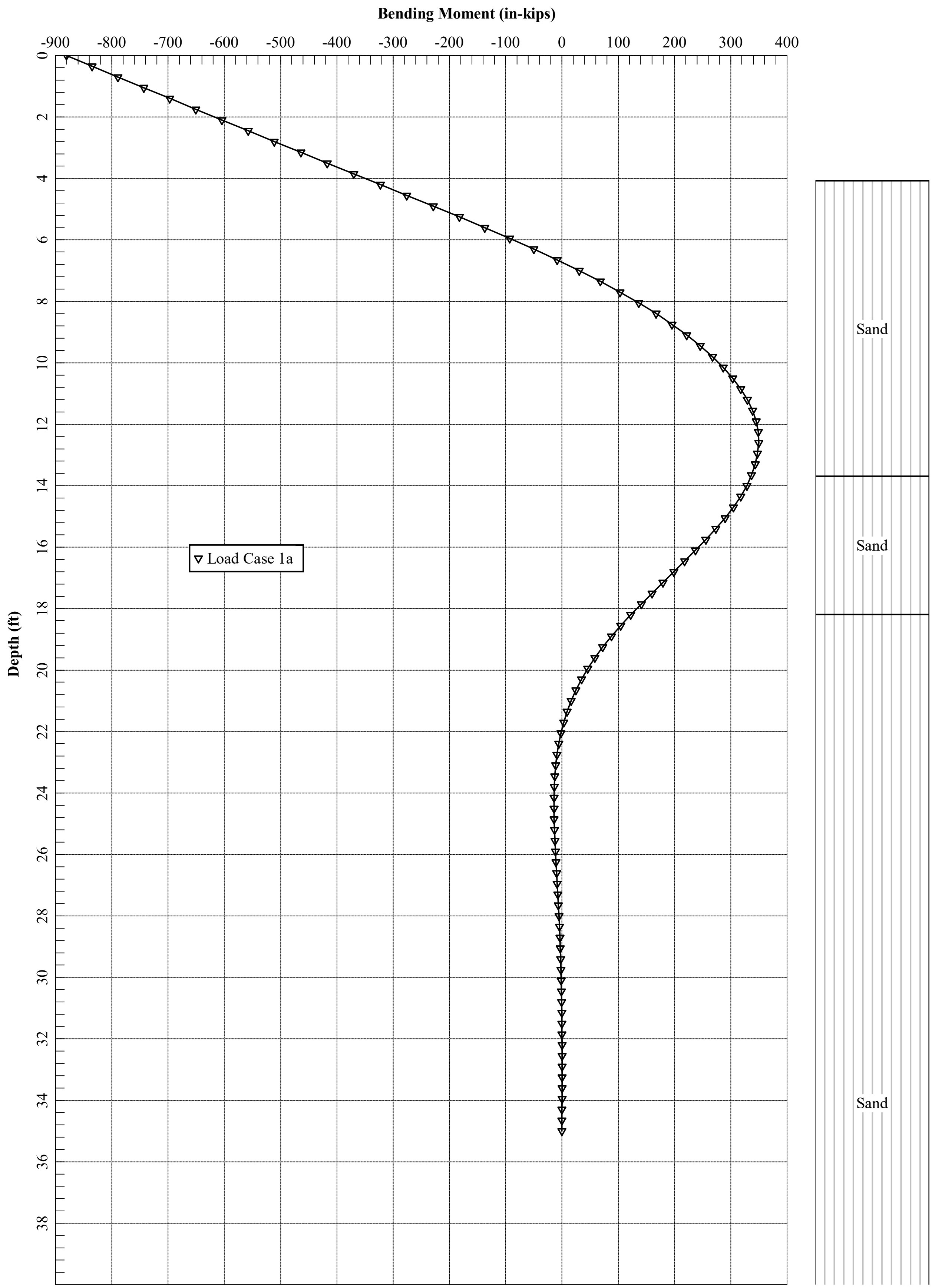
Maximum pile-head deflection = 0.3500000000 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

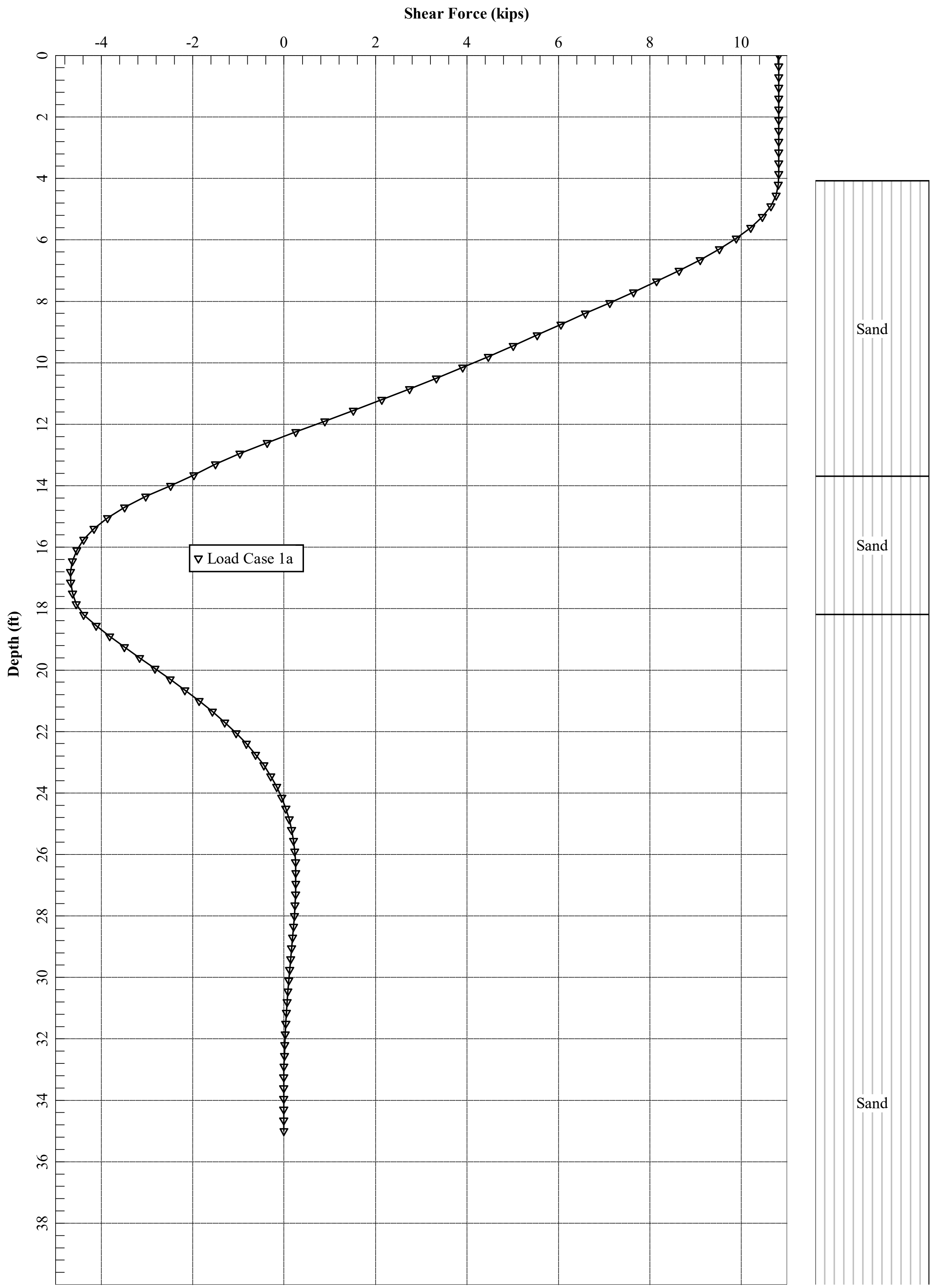
The analysis ended normally.

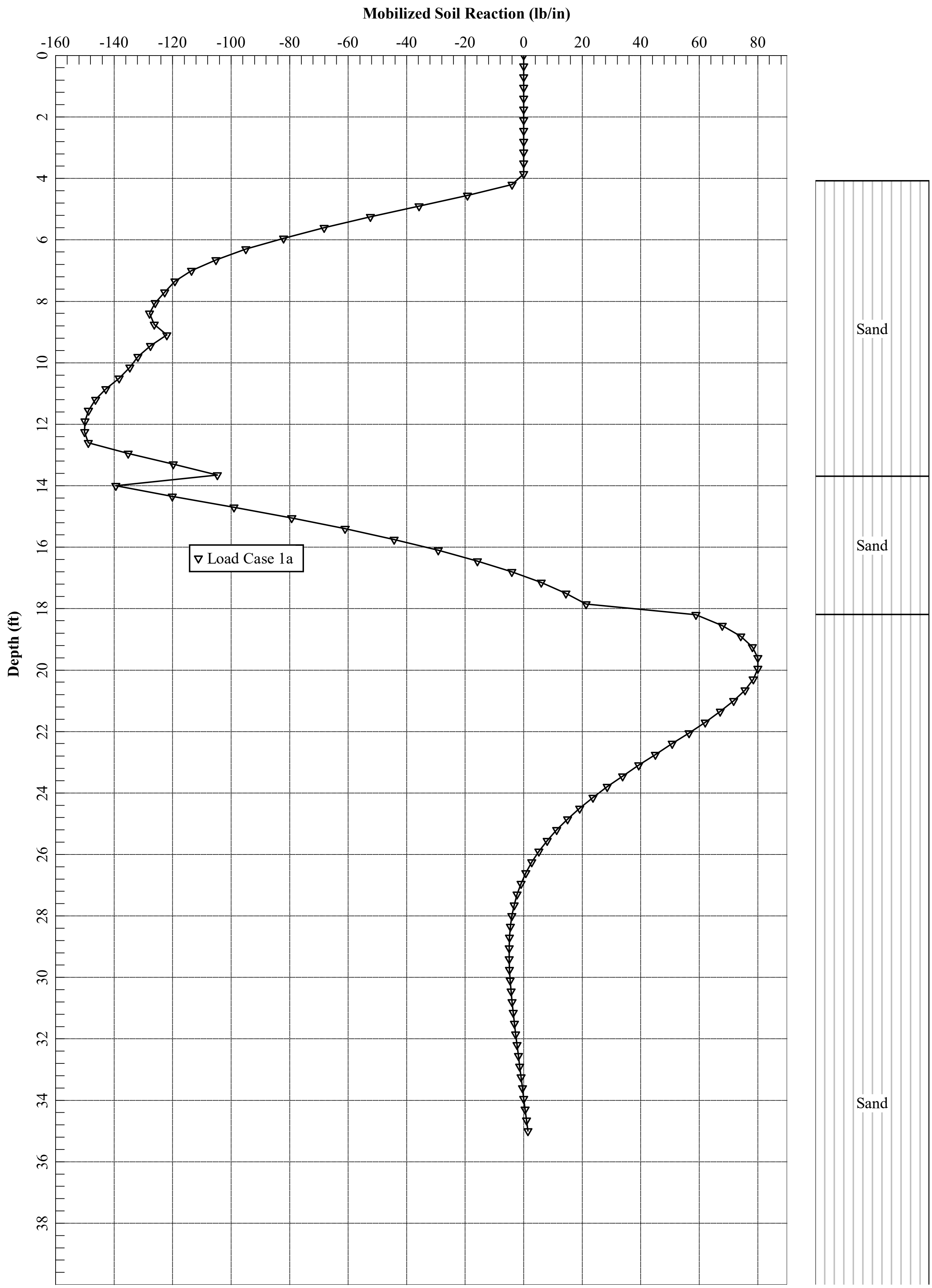


LPile 2018.10.09, © 2018 by Ensoft, Inc.


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1a
Sand
Sand
Sand


Bending Moment (in-kips)
-900
-800
-700
-600
-500
-400
-300
-200
-100
0
100
200
300
400
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1a
Sand
Sand
Sand


Shear Force (kips)
-4
-2
0
2
4
6
8
10
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1a
Sand
Sand
Sand


Mobilized Soil Reaction (lb/in)
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1a
Sand
Sand
Sand

==

LPile for Windows(Beta), Version 2018-10.009

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==

This copy of LPile is being used by:

GEI Consultants, Inc.
Woburn, MA

Serial Number of Security Device: 239146454

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Files Used for Analysis

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\Pile Length Estimate\LPILE 2020-02-25_Pier Piles\

Name of input data file:
1b. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Post Scour.lp10

Name of output report file:
1b. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Post Scour.lp10

Name of plot output file:
1b. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Post Scour.lp10

Name of runtime message file:

1b. Parallel to Cap - Br. Pier (weak axis, HP14x117)_Post Scour.lp10

Date and Time of Analysis

Date: March 16, 2020 Time: 11:03:57

Problem Title

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: AHK

Description: HP14x117_Bridge Pier (parallel)_Post Scour

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

```
Analysis Control Options:
 - Maximum number of iterations allowed                   =          500
 - Deflection tolerance for convergence                   =   1.0000E-05 in
 - Maximum allowable deflection                           =     100.0000 in
 - Number of pile increments                              =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                           =            1
Total length of pile                                      =       35.000 ft
Depth of ground surface below top of pile                 =      11.6800 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.
```

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.9000
2	35.000	14.9000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H weak axis steel pile
Length of section = 35.000000 ft
Pile width = 14.200000 in
Shear capacity of section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 11.680000 ft
Distance from top of pile to bottom of layer = 13.700000 ft
Effective unit weight at top of layer = 62.600000 pcf

```
   Effective unit weight at bottom of layer            =    62.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    13.700000 ft
   Distance from top of pile to bottom of layer        =    18.200000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    18.200000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

 (Depth of the lowest soil layer extends 15.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
```

Layer Num.	Name (p-y Curve Type)	Depth ft	Unit Wt. pcf	Friction deg.	kpy pci
1	Sand	11.6800	62.6000	30.0000	default
	(Reese, et al.)	13.7000	62.6000	30.0000	default
2	Sand	13.7000	67.6000	32.0000	default
	(Reese, et al.)	18.2000	67.6000	32.0000	default
3	Sand	18.2000	72.6000	38.0000	default
	(Reese, et al.)	50.0000	72.6000	38.0000	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	5	y = 0.350000 in	S = 0.0000 in/in	180000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

```
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Weak Axis:
---------------------------------------------

Length of Section                                  =    35.000000 ft
Flange Width                                       =    14.900000 in
Section Depth                                      =    14.200000 in
Flange Thickness                                   =     0.805000 in
Web Thickness                                      =     0.805000 in
Yield Stress of Pipe                               =    50.000000 ksi
Elastic Modulus                                    =       29000. ksi
Cross-sectional Area                               =    34.123950 sq. in.
Moment of Inertia                                  =   444.363799 in^4
Elastic Bending Stiffness                          =    12886550. kip-in^2
Plastic Modulus, Z                                 =    91.398684in^3
Plastic Moment Capacity = Fy Z                     =        4570.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As             =     1706.197 kips
Nominal Axial Tensile Capacity                     =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1             180.000

Definition of Run Messages:
```

Y = part of pipe section has yielded.

Axial Thrust Force = 180.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000484	62.3688228	12886018.	45.0308331	6.3101210	
0.00000968	124.7376457	12886018.	26.2404166	7.3453544	
0.00001452	187.1064685	12886018.	19.9769444	8.3805878	
0.00001936	249.4752914	12886018.	16.8452083	9.4158212	
0.00002420	311.8441142	12886018.	14.9661666	10.4510546	
0.00002904	374.2129371	12886018.	13.7134722	11.4862880	
0.00003388	436.5817599	12886018.	12.8186904	12.5215214	
0.00003872	498.9505828	12886018.	12.1476041	13.5567548	
0.00004356	561.3194056	12886018.	11.6256481	14.5919882	
0.00004840	623.6882285	12886018.	11.2080833	15.6272216	
0.00005324	686.0570513	12886018.	10.8664394	16.6624550	
0.00005808	748.4258741	12886018.	10.5817361	17.6976884	
0.00006292	810.7946970	12886018.	10.3408333	18.7329219	
0.00006776	873.1635198	12886018.	10.1343452	19.7681553	
0.00007260	935.5323427	12886018.	9.9553889	20.8033887	
0.00007744	997.9011655	12886018.	9.7988021	21.8386221	
0.00008228	1060.	12886018.	9.6606372	22.8738555	
0.00008712	1123.	12886018.	9.5378241	23.9090889	
0.00009196	1185.	12886018.	9.4279386	24.9443223	
0.00009680	1247.	12886018.	9.3290417	25.9795557	
0.0001016	1310.	12886018.	9.2395635	27.0147891	
0.0001065	1372.	12886018.	9.1582197	28.0500225	
0.0001113	1434.	12886018.	9.0839493	29.0852559	
0.0001162	1497.	12886018.	9.0158680	30.1204893	
0.0001210	1559.	12886018.	8.9532333	31.1557227	
0.0001258	1622.	12886018.	8.8954167	32.1909561	
0.0001307	1684.	12886018.	8.8418827	33.2261895	
0.0001355	1746.	12886018.	8.7921726	34.2614229	
0.0001404	1809.	12886018.	8.7458908	35.2966564	
0.0001452	1871.	12886018.	8.7026944	36.3318898	
0.0001500	1933.	12886018.	8.6622849	37.3671232	
0.0001549	1996.	12886018.	8.6244010	38.4023566	
0.0001597	2058.	12886018.	8.5888131	39.4375900	
0.0001646	2121.	12886018.	8.5553186	40.4728234	

0.0001694	2183.	12886018.	8.5237381	41.5080568	
0.0001742	2245.	12886018.	8.4939120	42.5432902	
0.0001791	2308.	12886018.	8.4656982	43.5785236	
0.0001839	2370.	12886018.	8.4389693	44.6137570	
0.0001888	2432.	12886018.	8.4136111	45.6489904	
0.0001984	2557.	12886018.	8.3666057	47.7194572	
0.0002081	2682.	12886018.	8.3239729	49.7899240	Y
0.0002178	2802.	12863270.	8.2882675	50.0000000	Y
0.0002275	2914.	12808474.	8.2604432	50.0000000	Y
0.0002372	3019.	12730671.	8.2389823	50.0000000	Y
0.0002468	3119.	12634556.	8.2229969	50.0000000	Y
0.0002565	3213.	12525649.	8.2114635	50.0000000	Y
0.0002662	3301.	12401279.	8.2024140	50.0000000	Y
0.0002759	3380.	12250582.	8.1935402	50.0000000	Y
0.0002856	3451.	12085228.	8.1849244	50.0000000	Y
0.0002952	3515.	11905763.	8.1764040	50.0000000	Y
0.0003049	3573.	11718902.	8.1682397	50.0000000	Y
0.0003146	3627.	11527414.	8.1602859	50.0000000	Y
0.0003243	3675.	11332602.	8.1523745	50.0000000	Y
0.0003340	3719.	11136787.	8.1446263	50.0000000	Y
0.0003436	3760.	10941551.	8.1370719	50.0000000	Y
0.0003533	3798.	10747977.	8.1296820	50.0000000	Y
0.0003630	3832.	10556967.	8.1224296	50.0000000	Y
0.0003727	3864.	10368817.	8.1153886	50.0000000	Y
0.0003824	3894.	10183089.	8.1084756	50.0000000	Y
0.0003920	3921.	10001546.	8.1016327	50.0000000	Y
0.0004017	3947.	9824626.	8.0948386	50.0000000	Y
0.0004114	3971.	9651298.	8.0885953	50.0000000	Y
0.0004211	3993.	9482079.	8.0821223	50.0000000	Y
0.0004308	4014.	9317199.	8.0757683	50.0000000	Y
0.0004404	4033.	9156826.	8.0698601	50.0000000	Y
0.0004501	4051.	9000406.	8.0636014	50.0000000	Y
0.0004598	4068.	8847985.	8.0578580	50.0000000	Y
0.0004695	4085.	8700220.	8.0519854	50.0000000	Y
0.0004792	4100.	8555772.	8.0463580	50.0000000	Y
0.0004888	4114.	8415953.	8.0408260	50.0000000	Y
0.0004985	4127.	8279427.	8.0352710	50.0000000	Y
0.0005082	4140.	8146928.	8.0300405	50.0000000	Y
0.0005179	4153.	8018210.	8.0245187	50.0000000	Y
0.0005276	4164.	7892476.	8.0195560	50.0000000	Y
0.0005372	4175.	7770646.	8.0144730	50.0000000	Y
0.0005469	4185.	7651935.	8.0093068	50.0000000	Y
0.0005566	4195.	7536626.	8.0047470	50.0000000	Y

0.0005663	4204.	7423949.	7.9996764	50.0000000	Y
0.0005760	4213.	7314831.	7.9948737	50.0000000	Y
0.0006147	4245.	6905354.	7.9768768	50.0000000	Y
0.0006534	4271.	6536288.	7.9597874	50.0000000	Y
0.0006921	4293.	6202837.	7.9437685	50.0000000	Y
0.0007308	4312.	5900172.	7.9288273	50.0000000	Y
0.0007696	4328.	5624461.	7.9149109	50.0000000	Y
0.0008083	4343.	5372811.	7.9016602	50.0000000	Y
0.0008470	4355.	5141927.	7.8891577	50.0000000	Y
0.0008857	4366.	4929338.	7.8771842	50.0000000	Y
0.0009244	4376.	4733544.	7.8660074	50.0000000	Y
0.0009632	4385.	4552268.	7.8553076	50.0000000	Y
0.0010019	4392.	4384047.	7.8452320	50.0000000	Y
0.0010406	4400.	4227890.	7.8354115	50.0000000	Y
0.0010793	4406.	4082001.	7.8264157	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	180.0000000000	4406.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	11.6800	0.00	N.A.	No	0.00	1493.
2	13.7000	1.8942	Yes	No	1493.	16743.
3	18.2000	5.1745	Yes	No	18236.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 0.350000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 180000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3500	-468079.	3774.	0.00	13122.	1.29E+10	0.00	0.00	0.00
0.3500	0.3497	-452171.	3774.	-1.50E-04	12856.	1.29E+10	0.00	0.00	0.00
0.7000	0.3487	-436151.	3774.	-2.95E-04	12587.	1.29E+10	0.00	0.00	0.00
1.0500	0.3472	-420025.	3774.	-4.34E-04	12317.	1.29E+10	0.00	0.00	0.00
1.4000	0.3451	-403794.	3774.	-5.69E-04	12045.	1.29E+10	0.00	0.00	0.00
1.7500	0.3424	-387465.	3774.	-6.97E-04	11771.	1.29E+10	0.00	0.00	0.00
2.1000	0.3392	-371039.	3774.	-8.21E-04	11496.	1.29E+10	0.00	0.00	0.00

2.4500	0.3355	-354523.	3774.	-9.39E-04	11219.	1.29E+10	0.00	0.00	0.00
2.8000	0.3313	-337919.	3774.	-0.00105	10940.	1.29E+10	0.00	0.00	0.00
3.1500	0.3267	-321231.	3774.	-0.00116	10661.	1.29E+10	0.00	0.00	0.00
3.5000	0.3216	-304465.	3774.	-0.00126	10379.	1.29E+10	0.00	0.00	0.00
3.8500	0.3161	-287623.	3774.	-0.00136	10097.	1.29E+10	0.00	0.00	0.00
4.2000	0.3102	-270711.	3774.	-0.00145	9814.	1.29E+10	0.00	0.00	0.00
4.5500	0.3039	-253732.	3774.	-0.00153	9529.	1.29E+10	0.00	0.00	0.00
4.9000	0.2973	-236690.	3774.	-0.00161	9243.	1.29E+10	0.00	0.00	0.00
5.2500	0.2904	-219590.	3774.	-0.00169	8956.	1.29E+10	0.00	0.00	0.00
5.6000	0.2831	-202436.	3774.	-0.00176	8669.	1.29E+10	0.00	0.00	0.00
5.9500	0.2756	-185232.	3774.	-0.00182	8380.	1.29E+10	0.00	0.00	0.00
6.3000	0.2678	-167983.	3774.	-0.00188	8091.	1.29E+10	0.00	0.00	0.00
6.6500	0.2598	-150692.	3774.	-0.00193	7801.	1.29E+10	0.00	0.00	0.00
7.0000	0.2516	-133364.	3774.	-0.00198	7511.	1.29E+10	0.00	0.00	0.00
7.3500	0.2432	-116003.	3774.	-0.00202	7220.	1.29E+10	0.00	0.00	0.00
7.7000	0.2347	-98613.	3774.	-0.00205	6928.	1.29E+10	0.00	0.00	0.00
8.0500	0.2260	-81200.	3774.	-0.00208	6636.	1.29E+10	0.00	0.00	0.00
8.4000	0.2172	-63766.	3774.	-0.00211	6344.	1.29E+10	0.00	0.00	0.00
8.7500	0.2083	-46316.	3774.	-0.00212	6051.	1.29E+10	0.00	0.00	0.00
9.1000	0.1993	-28855.	3774.	-0.00214	5759.	1.29E+10	0.00	0.00	0.00
9.4500	0.1904	-11387.	3774.	-0.00214	5466.	1.29E+10	0.00	0.00	0.00
9.8000	0.1814	6084.	3774.	-0.00214	5377.	1.29E+10	0.00	0.00	0.00
10.1500	0.1724	23553.	3774.	-0.00214	5670.	1.29E+10	0.00	0.00	0.00
10.5000	0.1634	41016.	3774.	-0.00213	5963.	1.29E+10	0.00	0.00	0.00
10.8500	0.1545	58470.	3774.	-0.00211	6255.	1.29E+10	0.00	0.00	0.00
11.2000	0.1457	75909.	3774.	-0.00209	6548.	1.29E+10	0.00	0.00	0.00
11.5500	0.1369	93329.	3774.	-0.00206	6840.	1.29E+10	0.00	0.00	0.00
11.9000	0.1283	110727.	3759.	-0.00203	7131.	1.29E+10	-7.2934	238.6650	0.00
12.2500	0.1199	127968.	3702.	-0.00199	7420.	1.29E+10	-19.7783	692.7844	0.00
12.6000	0.1116	144829.	3592.	-0.00195	7703.	1.29E+10	-32.6338	1228.	0.00
12.9500	0.1036	161079.	3429.	-0.00190	7975.	1.29E+10	-44.8171	1817.	0.00
13.3000	0.09572	176498.	3218.	-0.00184	8234.	1.29E+10	-55.7939	2448.	0.00
13.6500	0.08811	190890.	2964.	-0.00178	8475.	1.29E+10	-64.8883	3093.	0.00
14.0000	0.08076	204090.	2658.	-0.00172	8697.	1.29E+10	-80.8177	4203.	0.00
14.3500	0.07370	215814.	2303.	-0.00165	8893.	1.29E+10	-88.5656	5047.	0.00
14.7000	0.06692	225922.	1918.	-0.00158	9063.	1.29E+10	-94.3980	5924.	0.00
15.0500	0.06046	234310.	1517.	-0.00150	9203.	1.29E+10	-96.8116	6725.	0.00
15.4000	0.05432	240932.	1113.	-0.00142	9314.	1.29E+10	-95.6346	7394.	0.00
15.7500	0.04851	245808.	716.5416	-0.00134	9396.	1.29E+10	-93.0040	8053.	0.00
16.1000	0.04303	248983.	335.4876	-0.00126	9449.	1.29E+10	-88.4503	8633.	0.00
16.4500	0.03790	250536.	-19.2769	-0.00118	9475.	1.29E+10	-80.4851	8920.	0.00
16.8000	0.03311	250608.	-336.3217	-0.00110	9476.	1.29E+10	-70.4886	8942.	0.00
17.1500	0.02866	249374.	-631.7150	-0.00102	9456.	1.29E+10	-70.1749	10284.	0.00

17.5000	0.02455	246841.	-923.1303	-9.38E-04	9413.	1.29E+10	-68.5943	11735.	0.00
17.8500	0.02078	243038.	-1205.	-8.58E-04	9350.	1.29E+10	-65.7744	13293.	0.00
18.2000	0.01735	238014.	-1517.	-7.79E-04	9265.	1.29E+10	-82.6434	20011.	0.00
18.5500	0.01423	231474.	-1857.	-7.03E-04	9156.	1.29E+10	-79.1013	23340.	0.00
18.9000	0.01144	223481.	-2178.	-6.29E-04	9022.	1.29E+10	-73.7223	27065.	0.00
19.2500	0.00895	214133.	-2473.	-5.57E-04	8865.	1.29E+10	-66.8382	31356.	0.00
19.6000	0.00676	203553.	-2744.	-4.89E-04	8688.	1.29E+10	-62.5128	38852.	0.00
19.9500	0.00484	191820.	-2994.	-4.25E-04	8491.	1.29E+10	-56.3510	48883.	0.00
20.3000	0.00319	179046.	-3195.	-3.65E-04	8277.	1.29E+10	-39.5835	52147.	0.00
20.6500	0.00178	165529.	-3327.	-3.08E-04	8050.	1.29E+10	-22.9930	54265.	0.00
21.0000	5.98E-04	151566.	-3392.	-2.57E-04	7816.	1.29E+10	-8.0243	56382.	0.00
21.3500	-3.77E-04	137424.	-3398.	-2.10E-04	7579.	1.29E+10	5.2462	58499.	0.00
21.7000	-0.00116	123341.	-3352.	-1.67E-04	7343.	1.29E+10	16.7839	60617.	0.00
22.0500	-0.00178	109524.	-3260.	-1.29E-04	7111.	1.29E+10	26.5925	62734.	0.00
22.4000	-0.00225	96148.	-3132.	-9.56E-05	6887.	1.29E+10	34.7085	64851.	0.00
22.7500	-0.00258	83361.	-2972.	-6.64E-05	6672.	1.29E+10	41.1972	66969.	0.00
23.1000	-0.00281	71281.	-2789.	-4.12E-05	6470.	1.29E+10	46.1475	69086.	0.00
23.4500	-0.00293	59997.	-2588.	-1.98E-05	6281.	1.29E+10	49.6671	71204.	0.00
23.8000	-0.00297	49574.	-2374.	-1.93E-06	6106.	1.29E+10	51.8781	73321.	0.00
24.1500	-0.00295	40054.	-2154.	1.27E-05	5946.	1.29E+10	52.9126	75438.	0.00
24.5000	-0.00287	31458.	-1932.	2.43E-05	5802.	1.29E+10	52.9086	77556.	0.00
24.8500	-0.00274	23787.	-1712.	3.33E-05	5674.	1.29E+10	52.0064	79673.	0.00
25.2000	-0.00259	17027.	-1497.	4.00E-05	5560.	1.29E+10	50.3454	81790.	0.00
25.5500	-0.00241	11152.	-1290.	4.46E-05	5462.	1.29E+10	48.0611	83908.	0.00
25.9000	-0.00221	6122.	-1094.	4.74E-05	5378.	1.29E+10	45.2830	86025.	0.00
26.2500	-0.00201	1889.	-910.6843	4.87E-05	5307.	1.29E+10	42.1326	88142.	0.00
26.6000	-0.00180	-1602.	-740.8900	4.87E-05	5302.	1.29E+10	38.7218	90260.	0.00
26.9500	-0.00160	-4408.	-585.7557	4.78E-05	5349.	1.29E+10	35.1517	92377.	0.00
27.3000	-0.00140	-6594.	-445.7619	4.60E-05	5385.	1.29E+10	31.5120	94494.	0.00
27.6500	-0.00121	-8222.	-321.0370	4.36E-05	5413.	1.29E+10	27.8808	96612.	0.00
28.0000	-0.00103	-9357.	-211.4067	4.07E-05	5432.	1.29E+10	24.3241	98729.	0.00
28.3500	-8.70E-04	-10060.	-116.4444	3.75E-05	5444.	1.29E+10	20.8961	100846.	0.00
28.7000	-7.20E-04	-10392.	-35.5188	3.42E-05	5449.	1.29E+10	17.6399	102964.	0.00
29.0500	-5.83E-04	-10410.	32.1590	3.08E-05	5449.	1.29E+10	14.5876	105081.	0.00
29.4000	-4.61E-04	-10168.	87.4921	2.74E-05	5445.	1.29E+10	11.7615	107199.	0.00
29.7500	-3.52E-04	-9716.	131.4572	2.42E-05	5438.	1.29E+10	9.1743	109316.	0.00
30.1000	-2.57E-04	-9100.	165.0680	2.11E-05	5427.	1.29E+10	6.8308	111433.	0.00
30.4500	-1.75E-04	-8362.	189.3424	1.83E-05	5415.	1.29E+10	4.7284	113551.	0.00
30.8000	-1.04E-04	-7538.	205.2736	1.57E-05	5401.	1.29E+10	2.8579	115668.	0.00
31.1500	-4.30E-05	-6661.	213.8059	1.34E-05	5387.	1.29E+10	1.2051	117785.	0.00
31.5000	8.71E-06	-5762.	215.8144	1.14E-05	5371.	1.29E+10	-0.2487	119903.	0.00
31.8500	5.25E-05	-4866.	212.0886	9.63E-06	5356.	1.29E+10	-1.5255	122020.	0.00
32.2000	8.96E-05	-3995.	203.3212	8.19E-06	5342.	1.29E+10	-2.6495	124137.	0.00

32.5500	1.21E-04	-3170.	190.0995	7.02E-06	5328.	1.29E+10	-3.6466	126255.	0.00
32.9000	1.49E-04	-2409.	172.9014	6.11E-06	5315.	1.29E+10	-4.5430	128372.	0.00
33.2500	1.73E-04	-1727.	152.0958	5.44E-06	5304.	1.29E+10	-5.3645	130489.	0.00
33.6000	1.94E-04	-1139.	127.9458	4.97E-06	5294.	1.29E+10	-6.1355	132607.	0.00
33.9500	2.14E-04	-659.6811	100.6164	4.68E-06	5286.	1.29E+10	-6.8784	134724.	0.00
34.3000	2.34E-04	-301.2163	70.1861	4.52E-06	5280.	1.29E+10	-7.6122	136841.	0.00
34.6500	2.52E-04	-76.9562	36.6621	4.46E-06	5276.	1.29E+10	-8.3516	138959.	0.00
35.0000	2.71E-04	0.00	0.00	4.45E-06	5275.	1.29E+10	-9.1065	70538.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection              =     0.35000000 inches
Computed slope at pile head       =       0.000000 radians
Maximum bending moment            =       -468079. inch-lbs
Maximum shear force               =          3774. lbs
Depth of maximum bending moment   =       0.000000 feet below pile head
Depth of maximum shear force      =       0.000000 feet below pile head
Number of iterations              =              7
Number of zero deflection points =              2
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

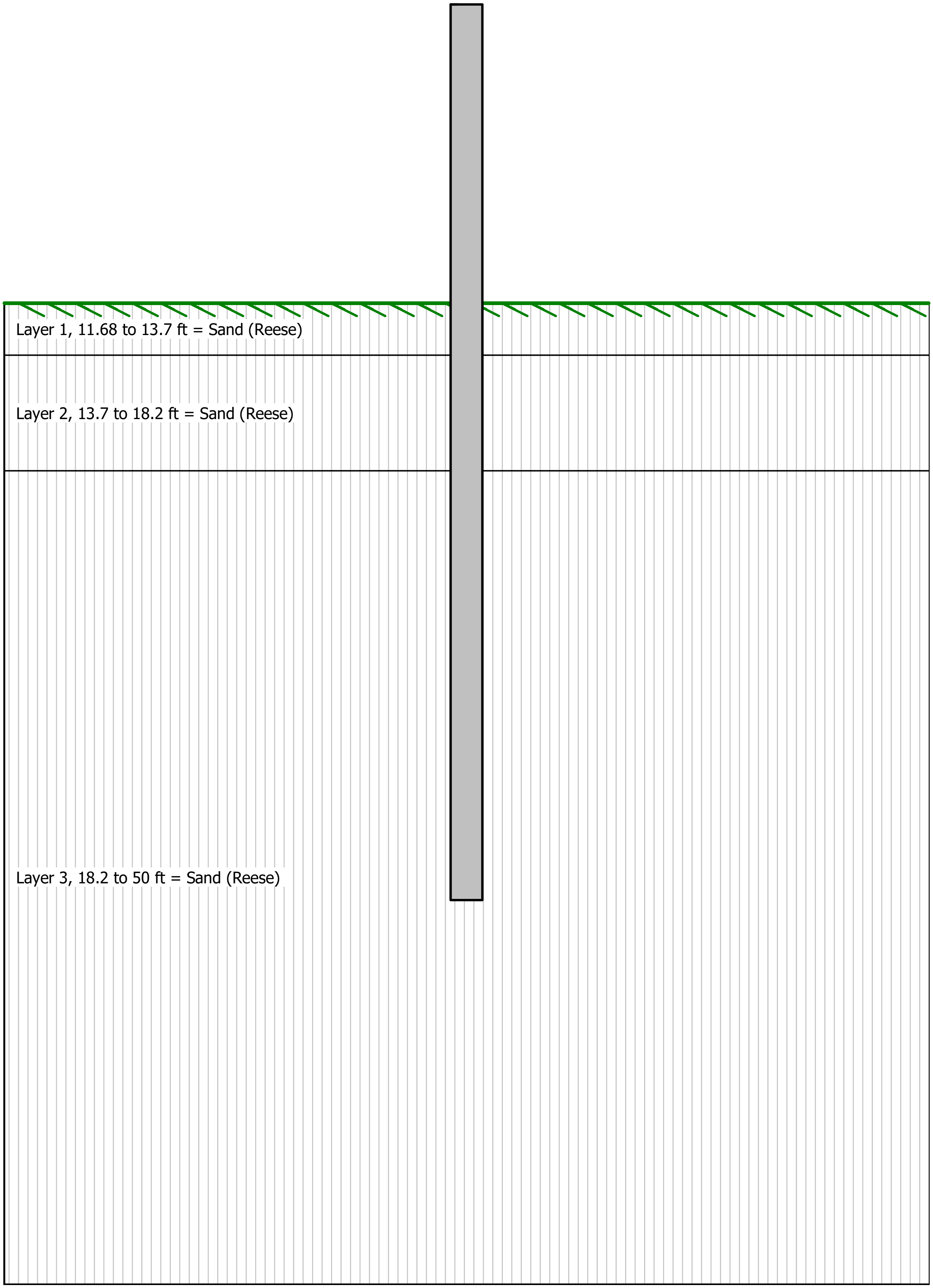
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Load Load Axial Pile-head Pile-head Max Shear Max Moment

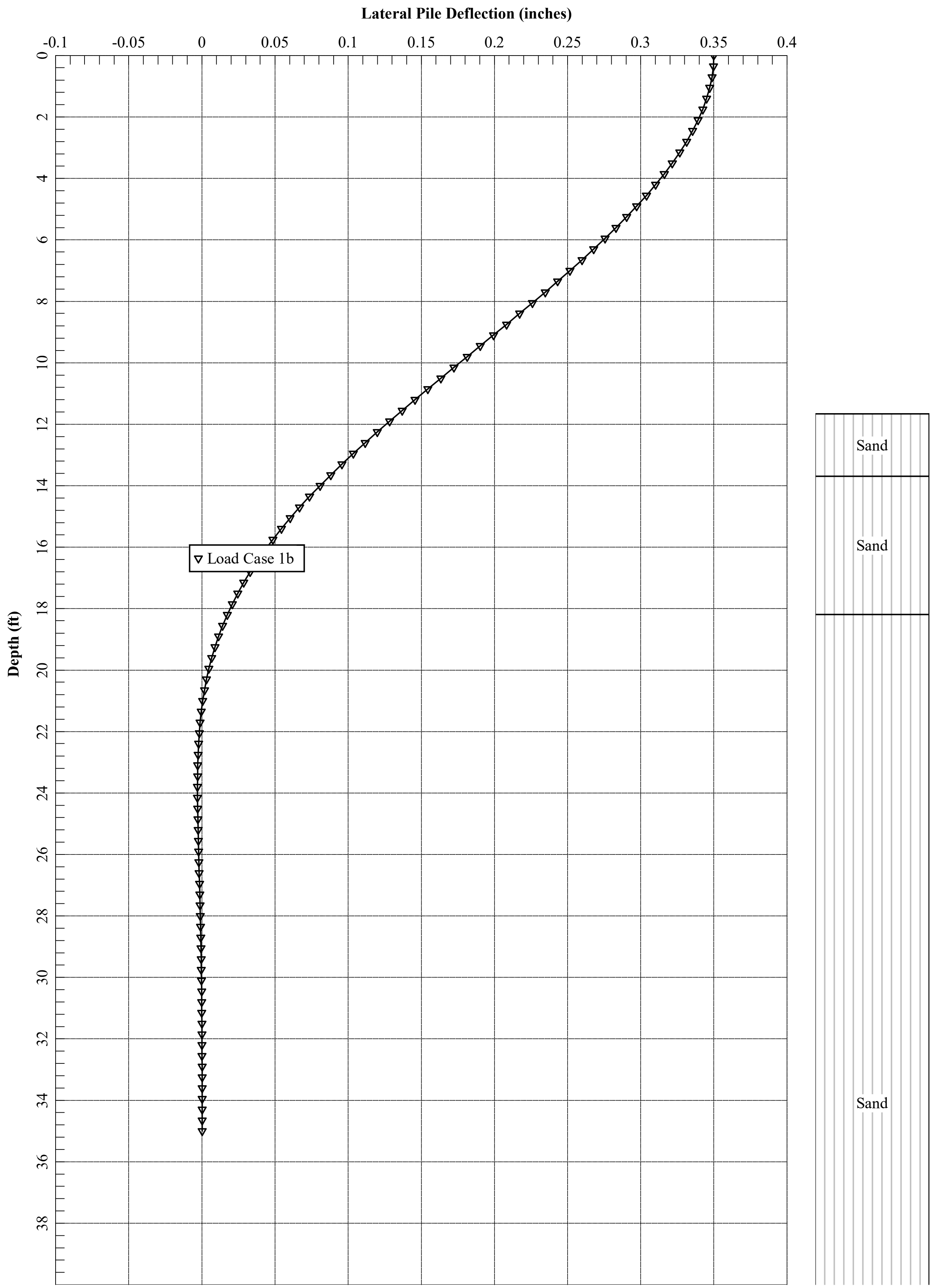
Case No.	Type 1	Pile-head Load 1	Type 2	Pile-head Load 2	Loading lbs	Deflection inches	Rotation radians	in Pile lbs	in Pile in-lbs
1	y, in	0.3500	S, rad	0.00	180000.	0.3500	0.00	3774.	-468079.

Maximum pile-head deflection = 0.3500000000 inches
Maximum pile-head rotation   = 0.0000000000 radians = 0.000000 deg.

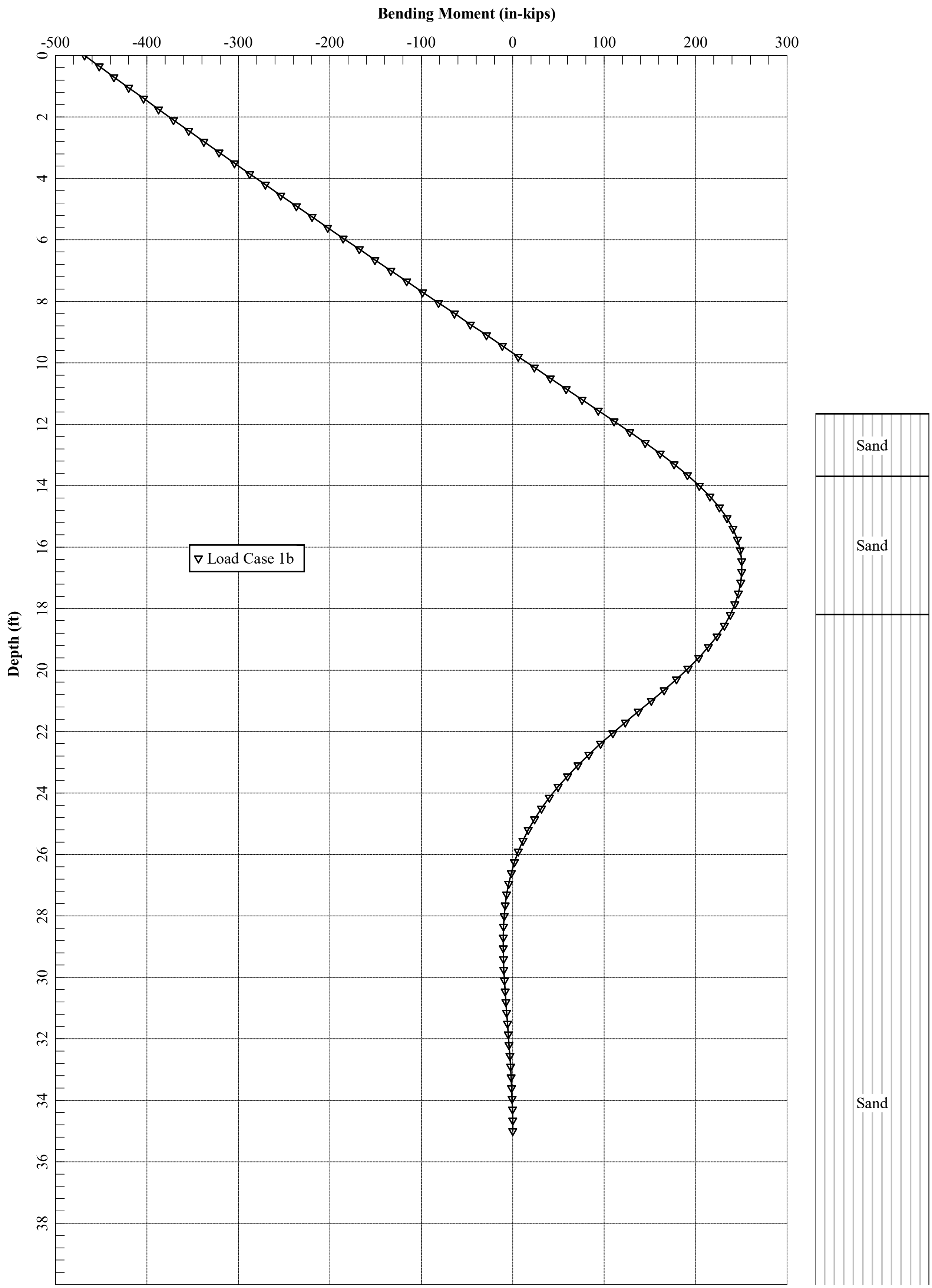
The analysis ended normally.

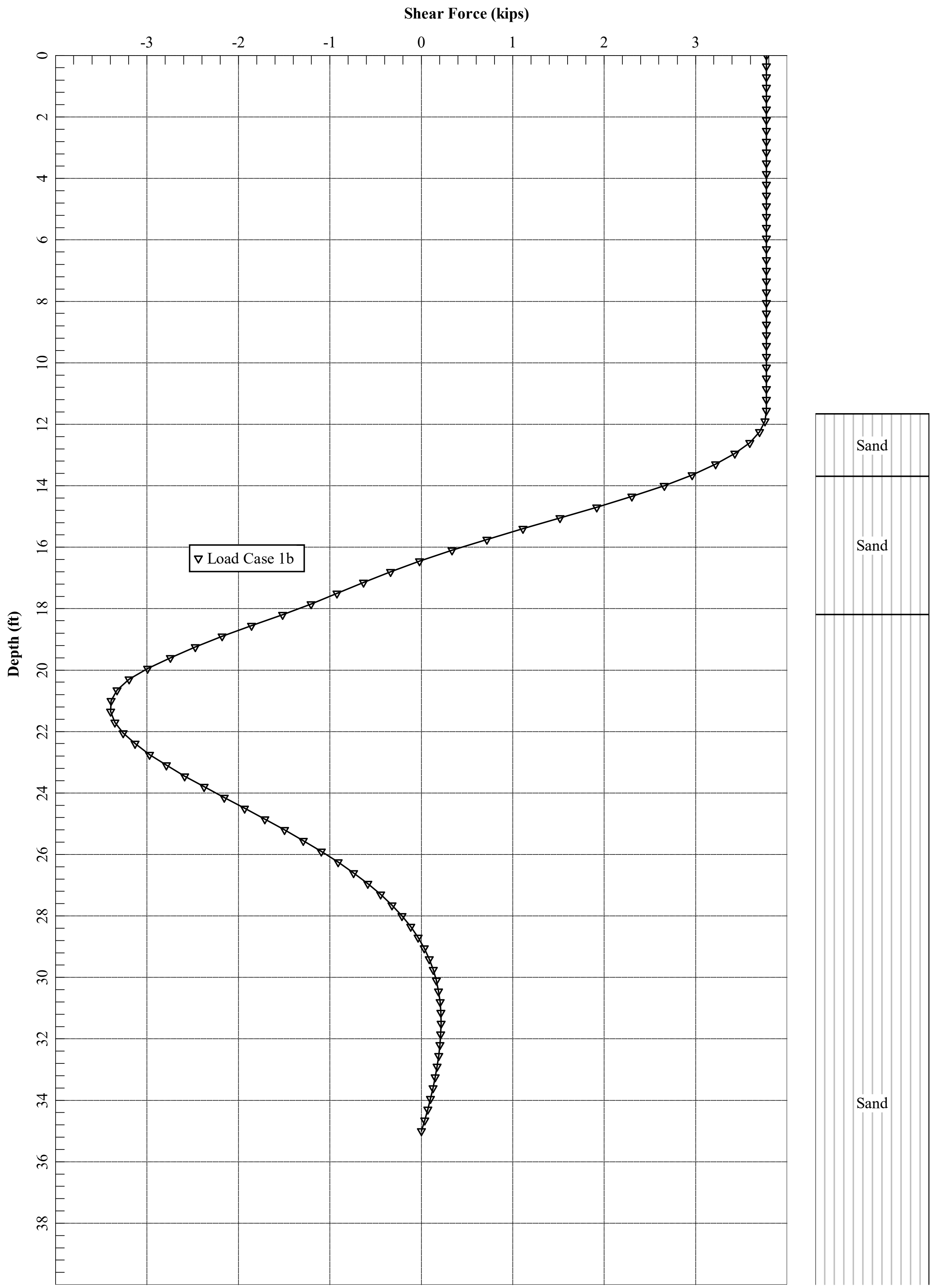


LPile 2018.10.09, © 2018 by Ensoft, Inc.

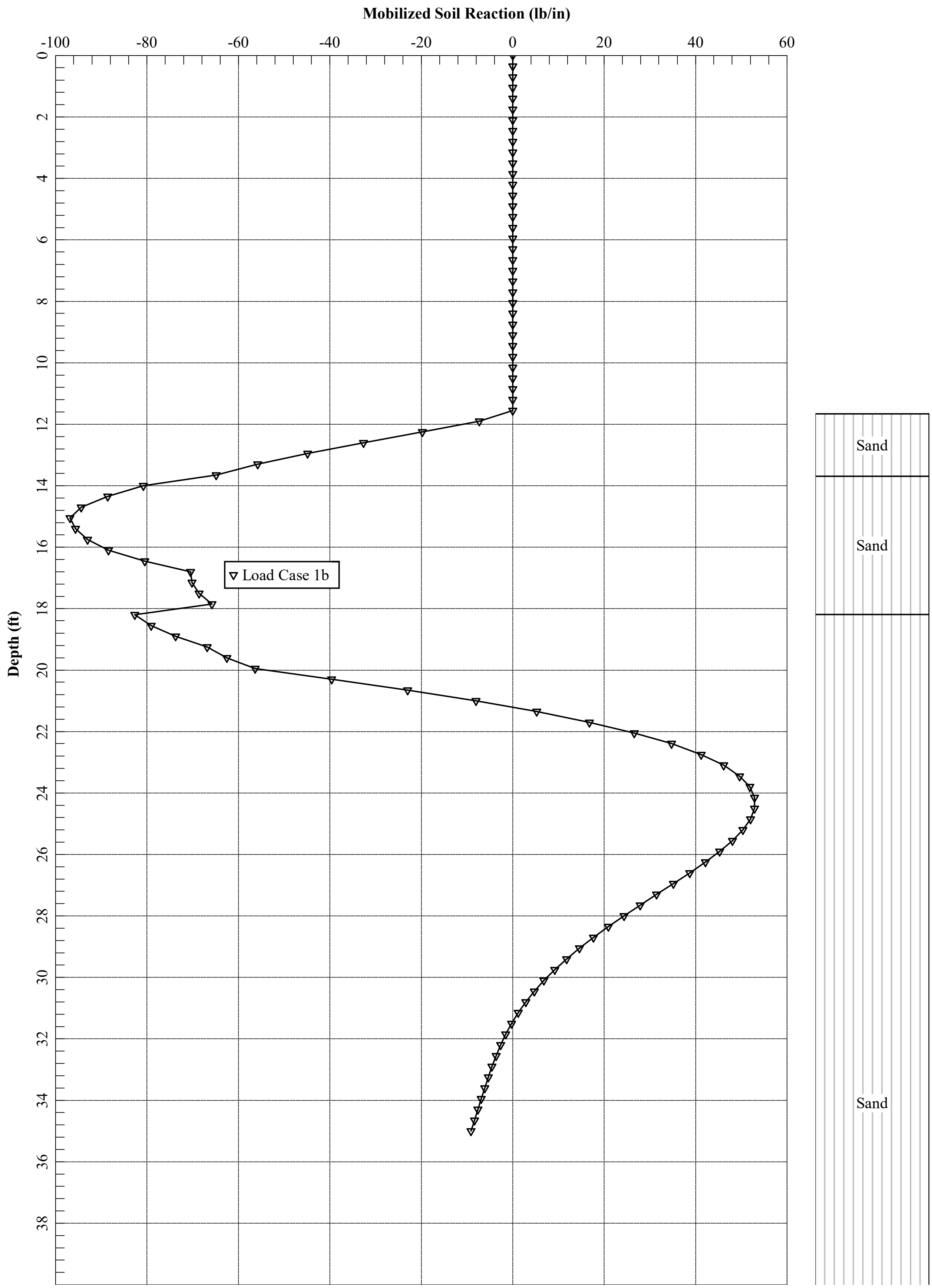


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1b
Sand
Sand
Sand


Bending Moment (in-kips)
-500
-400
-300
-200
-100
0
100
200
300
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1b
Sand
Sand
Sand



Shear Force (kips)
-3
-2
-1
0
1
2
3
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1b
Sand
Sand
Sand



Mobilized Soil Reaction (lb/in)
-100
-80
-60
-40
-20
0
20
40
60
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 1b
Sand
Sand
Sand

```
================================================================================

                  LPile for Windows(Beta), Version 2018-10.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\Pile Length Estimate\LPILE
2020-02-25_Pier Piles\

Name of input data file:
2a. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Pre Scour.lp10

Name of output report file:
2a. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Pre Scour.lp10

Name of plot output file:
2a. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Pre Scour.lp10

Name of runtime message file:
2a. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Pre Scour.lp10
```

```
--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

              Date:  March 16, 2020            Time:  11:07:56


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges


Job Number: 1703257


Client: HDR


Engineer: AHK


Description: HP14x117_Bridge Pier(perpendicular_Pre Scour)




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
```

```
 - Number of pile increments                              =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats




--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                          =            1
Total length of pile                                     =       35.000 ft
Depth of ground surface below top of pile                =       4.1000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.9000
  2           35.000           14.9000
```

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                  =    35.000000 ft
   Pile width                                         =    14.900000 in
   Shear capacity of section                          =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                    =        0.000 degrees
                                                      =        0.000 radians

Pile Batter Angle                                     =        0.000 degrees
                                                      =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =     4.100000 ft
   Distance from top of pile to bottom of layer       =    13.700000 ft
   Effective unit weight at top of layer              =    62.600000 pcf
   Effective unit weight at bottom of layer           =    62.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.
```

Layer 2 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    13.700000 ft
   Distance from top of pile to bottom of layer        =    18.200000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    18.200000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 15.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand	4.1000	62.6000	30.0000	default
	(Reese, et al.)	13.7000	62.6000	30.0000	default
2	Sand	13.7000	67.6000	32.0000	default
	(Reese, et al.)	18.2000	67.6000	32.0000	default
3	Sand	18.2000	72.6000	38.0000	default
	(Reese, et al.)	50.0000	72.6000	38.0000	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4	y = 0.400000 in	M = 0.0000 in-lbs	180000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel H Strong Axis:

```
Length of Section                                    =    35.000000 ft
Flange Width                                         =    14.900000 in
Section Depth                                        =    14.200000 in
Flange Thickness                                     =     0.805000 in
Web Thickness                                        =     0.805000 in
Yield Stress of Pipe                                 =    50.000000 ksi
Elastic Modulus                                      =       29000. ksi
Cross-sectional Area                                 =    34.123950 sq. in.
Moment of Inertia                                    =        1211. in^4
Elastic Bending Stiffness                            =    35125694. kip-in^2
Plastic Modulus, Z                                   =   192.566083in^3
Plastic Moment Capacity = Fy Z                       =        9628.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As               =     1706.197 kips
Nominal Axial Tensile Capacity                       =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1             180.000

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =    180.000 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000461	161.9087451	35100995.	46.5334094	6.2151356	
0.00000923	323.8174903	35100995.	26.8167047	7.1553836	
0.00001384	485.7262354	35100995.	20.2444698	8.0956316	
0.00001845	647.6349806	35100995.	16.9583523	9.0358797	
0.00002306	809.5437257	35100995.	14.9866819	9.9761277	

0.00002768	971.4524708	35100995.	13.6722349	10.9163757	
0.00003229	1133.	35100995.	12.7333442	11.8566237	
0.00003690	1295.	35100995.	12.0291762	12.7968718	
0.00004151	1457.	35100995.	11.4814899	13.7371198	
0.00004613	1619.	35100995.	11.0433409	14.6773678	
0.00005074	1781.	35100995.	10.6848554	15.6176159	
0.00005535	1943.	35100995.	10.3861174	16.5578639	
0.00005996	2105.	35100995.	10.1333392	17.4981119	
0.00006458	2267.	35100995.	9.9166721	18.4383599	
0.00006919	2429.	35100995.	9.7288940	19.3786080	
0.00007380	2591.	35100995.	9.5645881	20.3188560	
0.00007842	2752.	35100995.	9.4196123	21.2591040	
0.00008303	2914.	35100995.	9.2907450	22.1993520	
0.00008764	3076.	35100995.	9.1754426	23.1396001	
0.00009225	3238.	35100995.	9.0716705	24.0798481	
0.00009687	3400.	35100995.	8.9777814	25.0200961	
0.0001015	3562.	35100995.	8.8924277	25.9603441	
0.0001061	3724.	35100995.	8.8144961	26.9005922	
0.0001107	3886.	35100995.	8.7430587	27.8408402	
0.0001153	4048.	35100995.	8.6773364	28.7810882	
0.0001199	4210.	35100995.	8.6166696	29.7213362	
0.0001245	4372.	35100995.	8.5604966	30.6615843	
0.0001292	4533.	35100995.	8.5083360	31.6018323	
0.0001338	4695.	35100995.	8.4597727	32.5420803	
0.0001384	4857.	35100995.	8.4144470	33.4823283	
0.0001430	5019.	35100995.	8.3720455	34.4225764	
0.0001476	5181.	35100995.	8.3322940	35.3628244	
0.0001522	5343.	35100995.	8.2949518	36.3030724	
0.0001568	5505.	35100995.	8.2598062	37.2433204	
0.0001614	5667.	35100995.	8.2266688	38.1835685	
0.0001661	5829.	35100995.	8.1953725	39.1238165	
0.0001707	5991.	35100995.	8.1657678	40.0640645	
0.0001753	6153.	35100995.	8.1377213	41.0043125	
0.0001799	6314.	35100995.	8.1111131	41.9445606	
0.0001891	6638.	35100995.	8.0617905	43.8250566	
0.0001983	6962.	35100995.	8.0170560	45.7055527	
0.0002076	7286.	35100995.	7.9762980	47.5860487	
0.0002168	7610.	35100995.	7.9390087	49.4665448	
0.0002260	7904.	34969263.	7.9238050	50.0000000	Y
0.0002352	8120.	34516192.	7.9589877	50.0000000	Y
0.0002445	8236.	33690223.	8.0541460	50.0000000	Y
0.0002537	8330.	32836263.	8.1562682	50.0000000	Y
0.0002629	8418.	32015351.	8.2556890	50.0000000	Y
0.0002721	8499.	31227833.	8.3522036	50.0000000	Y
0.0002814	8574.	30472169.	8.4459146	50.0000000	Y

0.0002906	8644.	29746962.	8.5369034	50.0000000	Y
0.0002998	8710.	29050934.	8.6252336	50.0000000	Y
0.0003090	8772.	28382907.	8.7109528	50.0000000	Y
0.0003183	8829.	27741791.	8.7940948	50.0000000	Y
0.0003275	8884.	27126272.	8.8747434	50.0000000	Y
0.0003367	8932.	26525366.	8.9464583	50.0000000	Y
0.0003459	8977.	25947782.	9.0150017	50.0000000	Y
0.0003552	9016.	25384537.	9.0748055	50.0000000	Y
0.0003644	9053.	24842471.	9.1317845	50.0000000	Y
0.0003736	9085.	24314983.	9.1804104	50.0000000	Y
0.0003829	9114.	23806130.	9.2253945	50.0000000	Y
0.0003921	9140.	23310990.	9.2624600	50.0000000	Y
0.0004013	9162.	22831408.	9.2942738	50.0000000	Y
0.0004105	9181.	22363442.	9.3167440	50.0000000	Y
0.0004198	9196.	21908489.	9.3319767	50.0000000	Y
0.0004290	9207.	21462998.	9.3357841	50.0000000	Y
0.0004382	9216.	21031764.	9.3362901	50.0000000	Y
0.0004474	9225.	20617026.	9.3358424	50.0000000	Y
0.0004567	9233.	20217943.	9.3361421	50.0000000	Y
0.0004659	9240.	19833684.	9.3359388	50.0000000	Y
0.0004751	9247.	19463432.	9.3361020	50.0000000	Y
0.0004843	9254.	19106474.	9.3359250	50.0000000	Y
0.0004936	9260.	18762105.	9.3361689	50.0000000	Y
0.0005028	9266.	18429712.	9.3358009	50.0000000	Y
0.0005120	9272.	18108682.	9.3363442	50.0000000	Y
0.0005212	9277.	17798405.	9.3357186	50.0000000	Y
0.0005305	9282.	17498370.	9.3361978	50.0000000	Y
0.0005397	9287.	17208133.	9.3360220	50.0000000	Y
0.0005489	9291.	16927263.	9.3358286	50.0000000	Y
0.0005858	9308.	15888597.	9.3364121	50.0000000	Y
0.0006227	9321.	14968446.	9.3360220	50.0000000	Y
0.0006596	9332.	14148019.	9.3358499	50.0000000	Y
0.0006965	9342.	13412027.	9.3358894	50.0000000	Y
0.0007334	9350.	12748204.	9.3361421	50.0000000	Y
0.0007703	9357.	12146570.	9.3365596	50.0000000	Y
0.0008072	9363.	11598684.	9.3359250	50.0000000	Y
0.0008441	9368.	11097845.	9.3357448	50.0000000	Y
0.0008810	9372.	10638259.	9.3365861	50.0000000	Y
0.0009179	9377.	10215008.	9.3353951	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	180.0000000000	9377.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	4.1000	0.00	N.A.	No	0.00	41621.
2	13.7000	9.0386	Yes	No	41621.	84687.
3	18.2000	11.2840	Yes	No	126308.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.400000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 180000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4000	0.00	6845.	-0.00316	5275.	3.51E+10	0.00	0.00	0.00
0.3500	0.3867	31136.	6845.	-0.00316	5466.	3.51E+10	0.00	0.00	0.00
0.7000	0.3735	62269.	6845.	-0.00315	5658.	3.51E+10	0.00	0.00	0.00
1.0500	0.3603	93397.	6845.	-0.00314	5849.	3.51E+10	0.00	0.00	0.00
1.4000	0.3471	124516.	6845.	-0.00313	6041.	3.51E+10	0.00	0.00	0.00
1.7500	0.3340	155624.	6845.	-0.00311	6232.	3.51E+10	0.00	0.00	0.00
2.1000	0.3209	186717.	6845.	-0.00309	6423.	3.51E+10	0.00	0.00	0.00
2.4500	0.3080	217794.	6845.	-0.00307	6614.	3.51E+10	0.00	0.00	0.00
2.8000	0.2952	248851.	6845.	-0.00304	6806.	3.51E+10	0.00	0.00	0.00
3.1500	0.2825	279886.	6845.	-0.00301	6996.	3.51E+10	0.00	0.00	0.00
3.5000	0.2699	310895.	6845.	-0.00297	7187.	3.51E+10	0.00	0.00	0.00
3.8500	0.2575	341876.	6845.	-0.00293	7378.	3.51E+10	0.00	0.00	0.00
4.2000	0.2453	372827.	6837.	-0.00289	7568.	3.51E+10	-3.8062	65.1801	0.00
4.5500	0.2332	403676.	6790.	-0.00284	7758.	3.51E+10	-18.4328	331.9647	0.00
4.9000	0.2214	434164.	6680.	-0.00279	7945.	3.51E+10	-34.1315	647.5846	0.00
5.2500	0.2097	464010.	6503.	-0.00274	8129.	3.51E+10	-49.7818	996.8826	0.00
5.6000	0.1983	492937.	6263.	-0.00268	8307.	3.51E+10	-64.5127	1366.	0.00
5.9500	0.1872	520680.	5966.	-0.00262	8477.	3.51E+10	-77.2553	1733.	0.00
6.3000	0.1763	547014.	5617.	-0.00256	8639.	3.51E+10	-89.0003	2120.	0.00
6.6500	0.1657	571728.	5224.	-0.00249	8791.	3.51E+10	-98.1402	2488.	0.00
7.0000	0.1554	594660.	4796.	-0.00242	8933.	3.51E+10	-105.4668	2851.	0.00
7.3500	0.1454	615677.	4343.	-0.00235	9062.	3.51E+10	-110.1581	3183.	0.00
7.7000	0.1356	634695.	3876.	-0.00228	9179.	3.51E+10	-112.4258	3481.	0.00
8.0500	0.1262	651673.	3400.	-0.00220	9283.	3.51E+10	-114.2985	3803.	0.00
8.4000	0.1172	666575.	2918.	-0.00212	9375.	3.51E+10	-114.8580	4117.	0.00
8.7500	0.1084	679392.	2442.	-0.00204	9454.	3.51E+10	-111.9917	4337.	0.00
9.1000	0.1001	690171.	1983.	-0.00196	9520.	3.51E+10	-106.7957	4483.	0.00
9.4500	0.09201	699004.	1524.	-0.00187	9574.	3.51E+10	-111.3754	5084.	0.00

9.8000	0.08431	705809.	1049.	-0.00179	9616.	3.51E+10	-114.7913	5718.	0.00
10.1500	0.07697	710525.	562.7604	-0.00170	9645.	3.51E+10	-116.9609	6382.	0.00
10.5000	0.06999	713113.	64.7971	-0.00162	9661.	3.51E+10	-120.1645	7211.	0.00
10.8500	0.06337	713518.	-448.8671	-0.00153	9664.	3.51E+10	-124.4375	8248.	0.00
11.2000	0.05710	711663.	-978.8435	-0.00145	9652.	3.51E+10	-127.9322	9409.	0.00
11.5500	0.05120	707487.	-1522.	-0.00136	9626.	3.51E+10	-130.5939	10713.	0.00
11.9000	0.04565	700943.	-2074.	-0.00128	9586.	3.51E+10	-132.3735	12180.	0.00
12.2500	0.04045	692000.	-2632.	-0.00120	9531.	3.51E+10	-133.2271	13835.	0.00
12.6000	0.03559	680645.	-3175.	-0.00111	9461.	3.51E+10	-125.4192	14799.	0.00
12.9500	0.03108	667016.	-3678.	-0.00103	9378.	3.51E+10	-114.0395	15408.	0.00
13.3000	0.02691	651315.	-4133.	-9.55E-04	9281.	3.51E+10	-102.6296	16018.	0.00
13.6500	0.02306	633745.	-4540.	-8.78E-04	9173.	3.51E+10	-91.3043	16627.	0.00
14.0000	0.01953	614506.	-4998.	-8.03E-04	9055.	3.51E+10	-126.7770	27257.	0.00
14.3500	0.01632	592976.	-5494.	-7.31E-04	8922.	3.51E+10	-109.6250	28221.	0.00
14.7000	0.01339	569459.	-5920.	-6.62E-04	8777.	3.51E+10	-93.0663	29184.	0.00
15.0500	0.01076	544248.	-6278.	-5.95E-04	8622.	3.51E+10	-77.2212	30148.	0.00
15.4000	0.00840	517626.	-6570.	-5.31E-04	8459.	3.51E+10	-62.1927	31112.	0.00
15.7500	0.00629	489859.	-6802.	-4.71E-04	8288.	3.51E+10	-48.0670	32075.	0.00
16.1000	0.00444	461201.	-6976.	-4.14E-04	8112.	3.51E+10	-34.9133	33039.	0.00
16.4500	0.00281	431885.	-7097.	-3.61E-04	7931.	3.51E+10	-22.7845	34003.	0.00
16.8000	0.00141	402128.	-7170.	-3.11E-04	7748.	3.51E+10	-11.7176	34966.	0.00
17.1500	2.03E-04	372128.	-7198.	-2.65E-04	7564.	3.51E+10	-1.7338	35930.	0.00
17.5000	-8.15E-04	342064.	-7187.	-2.22E-04	7379.	3.51E+10	7.1600	36894.	0.00
17.8500	-0.00166	312095.	-7140.	-1.83E-04	7195.	3.51E+10	14.9714	37857.	0.00
18.2000	-0.00235	282362.	-7009.	-1.47E-04	7012.	3.51E+10	47.7270	85299.	0.00
18.5500	-0.00290	253445.	-6782.	-1.15E-04	6834.	3.51E+10	60.2993	87416.	0.00
18.9000	-0.00332	225569.	-6507.	-8.64E-05	6662.	3.51E+10	70.7081	89534.	0.00
19.2500	-0.00362	198920.	-6192.	-6.11E-05	6498.	3.51E+10	79.0665	91651.	0.00
19.6000	-0.00383	173648.	-5847.	-3.88E-05	6343.	3.51E+10	85.5019	93768.	0.00
19.9500	-0.00395	149868.	-5478.	-1.94E-05	6197.	3.51E+10	90.1531	95886.	0.00
20.3000	-0.00399	127665.	-5093.	-2.80E-06	6060.	3.51E+10	93.1671	98003.	0.00
20.6500	-0.00397	107094.	-4698.	1.12E-05	5934.	3.51E+10	94.6959	100120.	0.00
21.0000	-0.00390	88184.	-4300.	2.29E-05	5817.	3.51E+10	94.8941	102238.	0.00
21.3500	-0.00378	70939.	-3904.	3.24E-05	5711.	3.51E+10	93.9164	104355.	0.00
21.7000	-0.00363	55345.	-3513.	4.00E-05	5615.	3.51E+10	91.9156	106473.	0.00
22.0500	-0.00344	41367.	-3133.	4.58E-05	5529.	3.51E+10	89.0402	108590.	0.00
22.4000	-0.00324	28956.	-2767.	5.00E-05	5453.	3.51E+10	85.4335	110707.	0.00
22.7500	-0.00302	18050.	-2417.	5.28E-05	5386.	3.51E+10	81.2315	112825.	0.00
23.1000	-0.00280	8575.	-2085.	5.44E-05	5328.	3.51E+10	76.5622	114942.	0.00
23.4500	-0.00257	449.6342	-1774.	5.49E-05	5278.	3.51E+10	71.5447	117059.	0.00
23.8000	-0.00234	-6414.	-1485.	5.46E-05	5314.	3.51E+10	66.2881	119177.	0.00
24.1500	-0.00211	-12107.	-1218.	5.35E-05	5349.	3.51E+10	60.8919	121294.	0.00
24.5000	-0.00189	-16725.	-973.6372	5.17E-05	5378.	3.51E+10	55.4450	123411.	0.00
24.8500	-0.00167	-20364.	-752.1485	4.95E-05	5400.	3.51E+10	50.0258	125529.	0.00
25.2000	-0.00147	-23118.	-553.2182	4.69E-05	5417.	3.51E+10	44.7029	127646.	0.00

25.5500	-0.00128	-25082.	-376.3203	4.40E-05	5429.	3.51E+10	39.5342	129763.	0.00
25.9000	-0.00110	-26346.	-220.7044	4.10E-05	5437.	3.51E+10	34.5685	131881.	0.00
26.2500	-9.35E-04	-26998.	-85.4358	3.78E-05	5441.	3.51E+10	29.8451	133998.	0.00
26.6000	-7.84E-04	-27121.	30.5675	3.45E-05	5442.	3.51E+10	25.3946	136115.	0.00
26.9500	-6.45E-04	-26793.	128.4989	3.13E-05	5440.	3.51E+10	21.2395	138233.	0.00
27.3000	-5.21E-04	-26089.	209.6311	2.81E-05	5435.	3.51E+10	17.3949	140350.	0.00
27.6500	-4.09E-04	-25075.	275.2859	2.51E-05	5429.	3.51E+10	13.8693	142468.	0.00
28.0000	-3.10E-04	-23814.	326.8077	2.22E-05	5421.	3.51E+10	10.6649	144585.	0.00
28.3500	-2.23E-04	-22363.	365.5390	1.94E-05	5412.	3.51E+10	7.7786	146702.	0.00
28.7000	-1.47E-04	-20773.	392.7998	1.68E-05	5403.	3.51E+10	5.2027	148820.	0.00
29.0500	-8.14E-05	-19089.	409.8690	1.44E-05	5392.	3.51E+10	2.9255	150937.	0.00
29.4000	-2.56E-05	-17352.	417.9696	1.23E-05	5382.	3.51E+10	0.9319	153054.	0.00
29.7500	2.15E-05	-15597.	418.2555	1.03E-05	5371.	3.51E+10	-0.7958	155172.	0.00
30.1000	6.08E-05	-13854.	411.8017	8.52E-06	5360.	3.51E+10	-2.2775	157289.	0.00
30.4500	9.31E-05	-12150.	399.5966	6.97E-06	5350.	3.51E+10	-3.5345	159406.	0.00
30.8000	1.19E-04	-10508.	382.5367	5.61E-06	5340.	3.51E+10	-4.5893	161524.	0.00
31.1500	1.40E-04	-8946.	361.4235	4.45E-06	5330.	3.51E+10	-5.4647	163641.	0.00
31.5000	1.57E-04	-7479.	336.9616	3.46E-06	5321.	3.51E+10	-6.1838	165758.	0.00
31.8500	1.69E-04	-6120.	309.7602	2.65E-06	5313.	3.51E+10	-6.7693	167876.	0.00
32.2000	1.79E-04	-4881.	280.3344	1.99E-06	5305.	3.51E+10	-7.2430	169993.	0.00
32.5500	1.86E-04	-3769.	249.1097	1.48E-06	5298.	3.51E+10	-7.6259	172110.	0.00
32.9000	1.91E-04	-2791.	216.4268	1.08E-06	5292.	3.51E+10	-7.9374	174228.	0.00
33.2500	1.95E-04	-1952.	182.5479	7.99E-07	5287.	3.51E+10	-8.1954	176345.	0.00
33.6000	1.98E-04	-1258.	147.6651	6.07E-07	5283.	3.51E+10	-8.4155	178463.	0.00
33.9500	2.00E-04	-712.7477	111.9087	4.89E-07	5279.	3.51E+10	-8.6113	180580.	0.00
34.3000	2.02E-04	-319.0206	75.3578	4.27E-07	5277.	3.51E+10	-8.7938	182697.	0.00
34.6500	2.04E-04	-80.3881	38.0512	4.03E-07	5275.	3.51E+10	-8.9712	184815.	0.00
35.0000	2.06E-04	0.00	0.00	3.98E-07	5275.	3.51E+10	-9.1485	93466.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.40000000 inches
Computed slope at pile head      =    -0.00315899 radians
Maximum bending moment           =        713518. inch-lbs
Maximum shear force              =         -7198. lbs
Depth of maximum bending moment  =    10.85000000 feet below pile head
Depth of maximum shear force     =    17.15000000 feet below pile head
```

Number of iterations = 6
Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

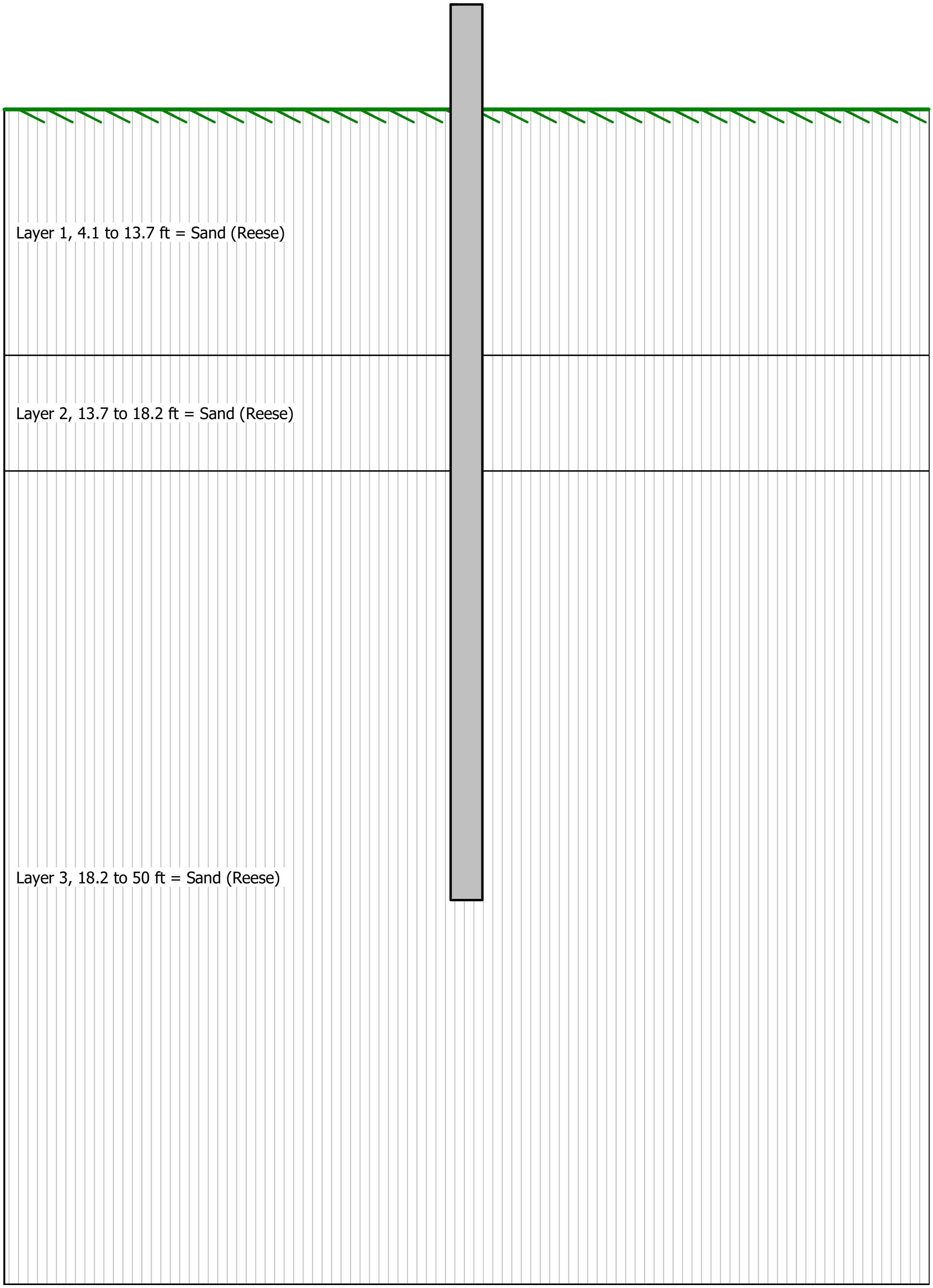
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

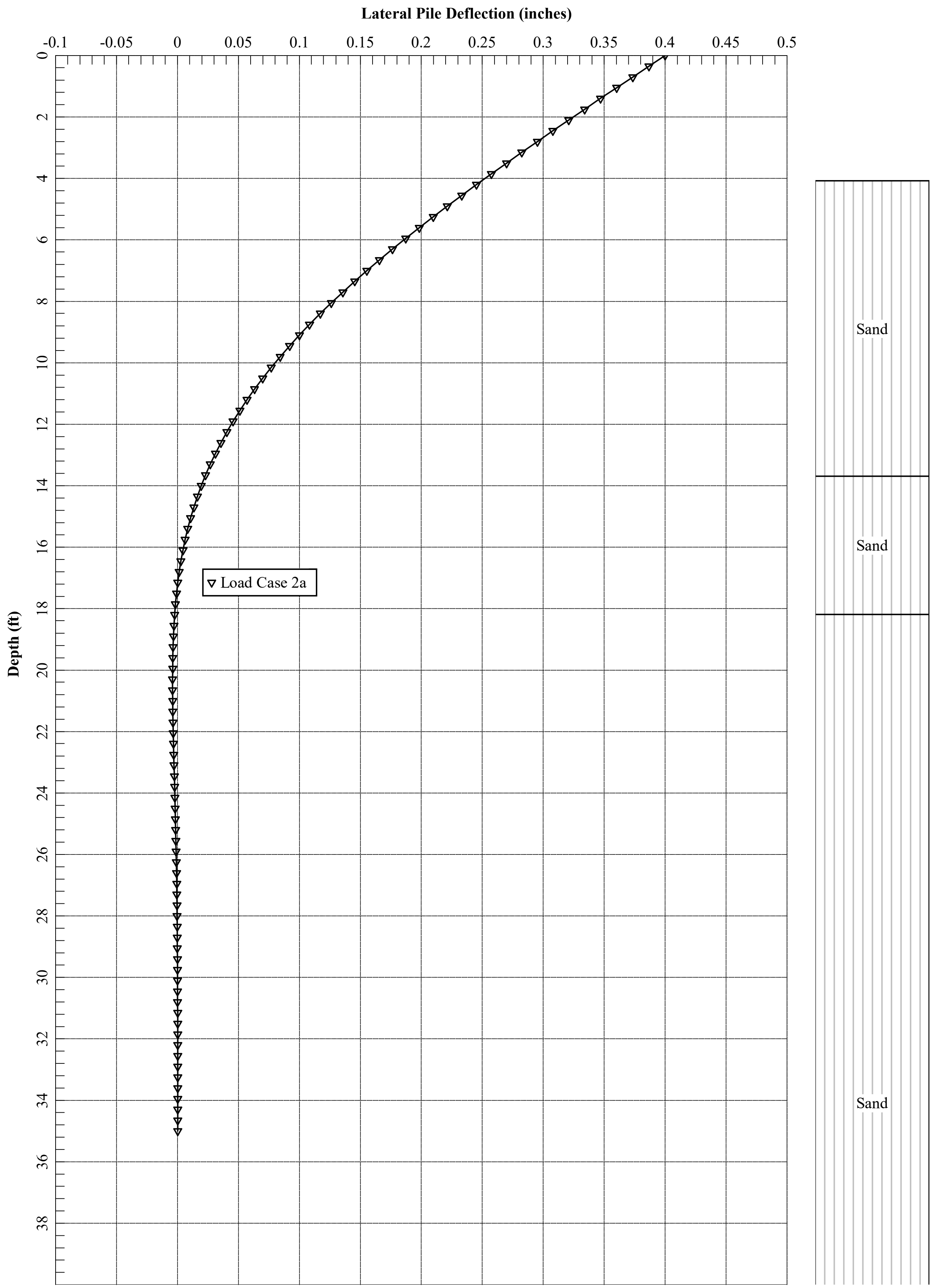
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4000	M, in-lb	0.00	180000.	0.4000	-0.00316	-7198.	713518.

Maximum pile-head deflection = 0.4000000000 inches
Maximum pile-head rotation = -0.0031589882 radians = -0.180997 deg.

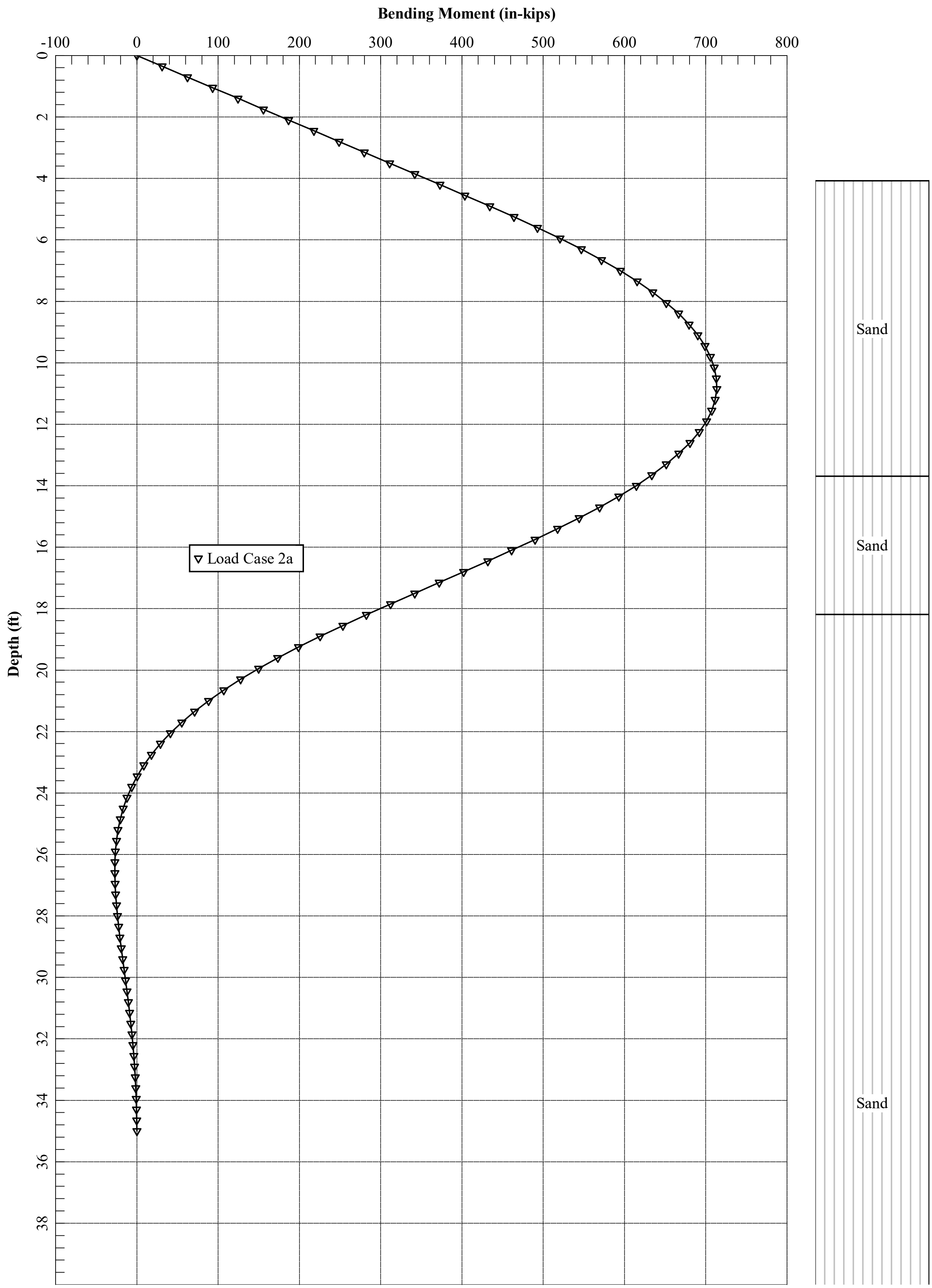
The analysis ended normally.

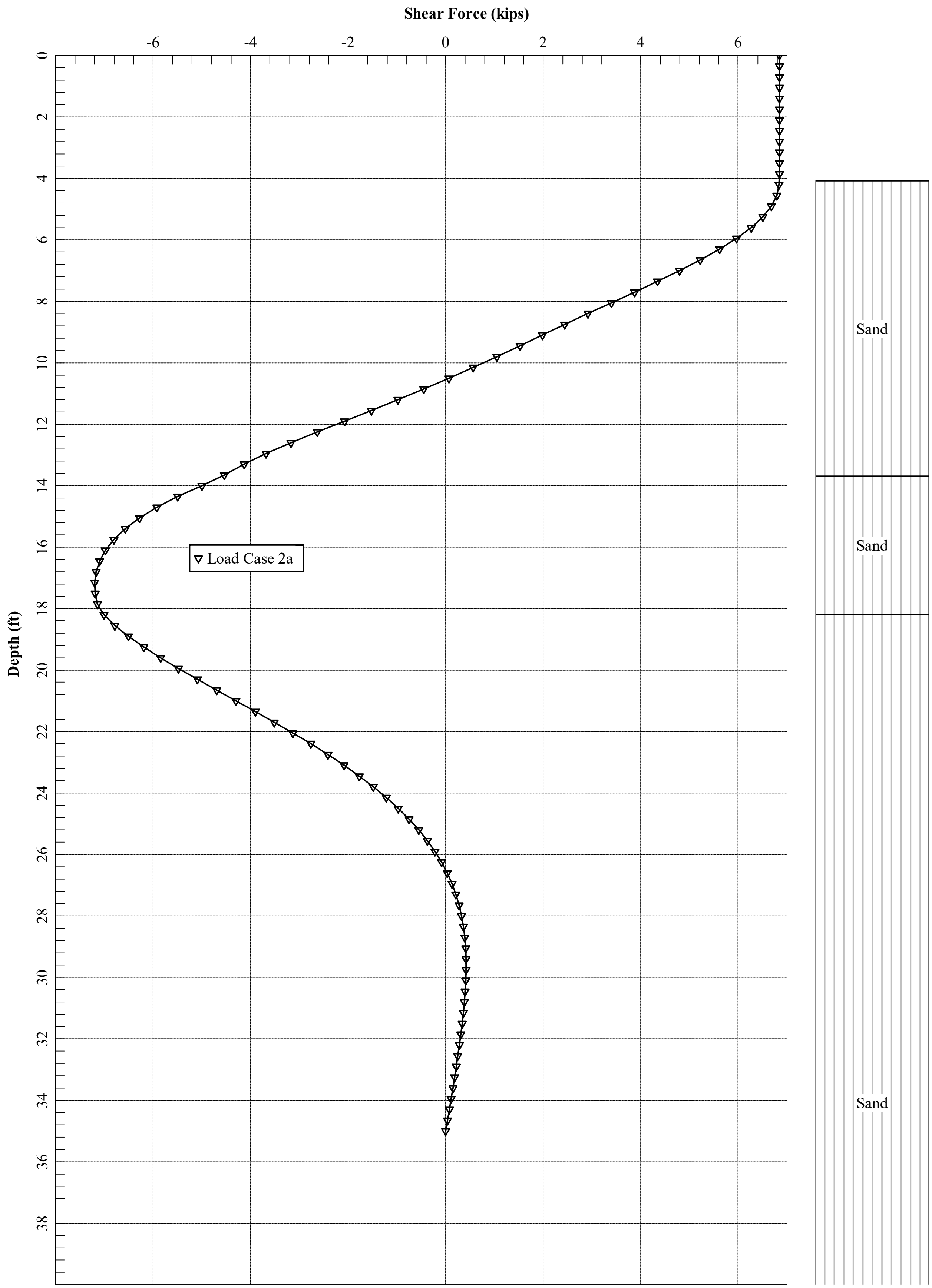


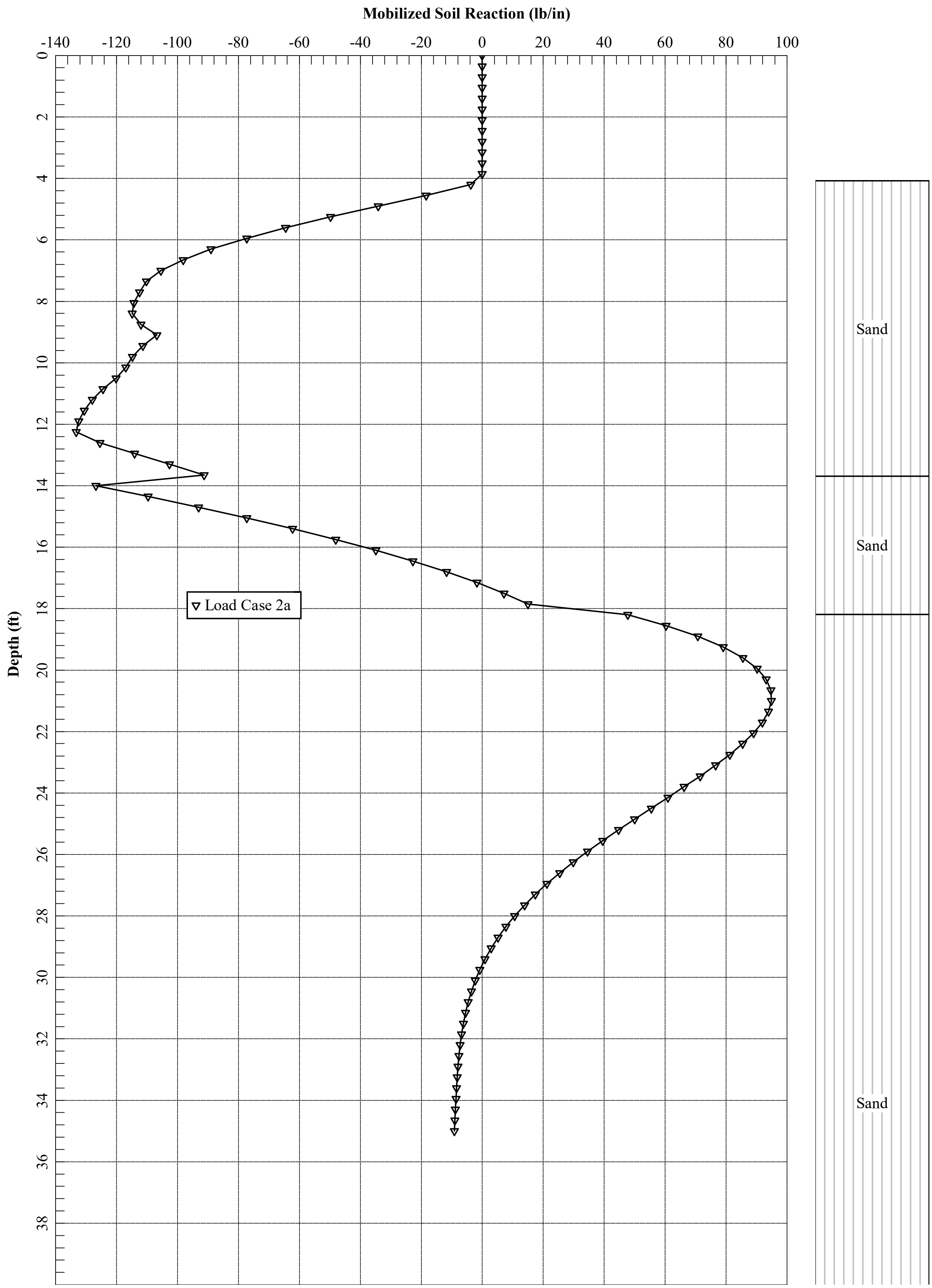
LPile 2018.10.09, © 2018 by Ensoft, Inc.



Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2a
Sand
Sand
Sand


Bending Moment (in-kips)
-100
0
100
200
300
400
500
600
700
800
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2a
Sand
Sand
Sand


Shear Force (kips)
-6
-4
-2
0
2
4
6
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2a
Sand
Sand
Sand


Mobilized Soil Reaction (lb/in)
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2a
Sand
Sand
Sand

```
================================================================================

                 LPile for Windows(Beta), Version 2018-10.009

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\12_Design Recommendations\Bridge 77.16\Pile Length Estimate\LPILE
2020-02-25_Pier Piles\

Name of input data file:
2b. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Post Scour - Copy.lp10

Name of output report file:
2b. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Post Scour - Copy.lp10

Name of plot output file:
2b. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Post Scour - Copy.lp10

Name of runtime message file:
2b. Perp. to Cap - Br. Pier (strong axis, HP14x117)_Post Scour - Copy.lp10
```

```
--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  March 16, 2020             Time:  11:12:31


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 77.16, HDR-MassDOT Railroad Bridges


Job Number: 1703257


Client: HDR


Engineer: AHK


Description: HP14x117_Bridge Pier(perpendicular)_Post Scour




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
```

- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 35.000 ft
Depth of ground surface below top of pile = 11.6800 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.9000
2	35.000	14.9000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                    =    35.000000 ft
   Pile width                                           =    14.900000 in
   Shear capacity of section                            =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

Pile Batter Angle                                       =        0.000 degrees
                                                        =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =    11.680000 ft
   Distance from top of pile to bottom of layer         =    13.700000 ft
   Effective unit weight at top of layer                =    62.600000 pcf
   Effective unit weight at bottom of layer             =    62.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =       0.0000 pci
   Subgrade k at bottom of layer                        =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.
```

Layer 2 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    13.700000 ft
   Distance from top of pile to bottom of layer        =    18.200000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    18.200000 ft
   Distance from top of pile to bottom of layer        =    50.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 15.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand	11.6800	62.6000	30.0000	default
	(Reese, et al.)	13.7000	62.6000	30.0000	default
2	Sand	13.7000	67.6000	32.0000	default
	(Reese, et al.)	18.2000	67.6000	32.0000	default
3	Sand	18.2000	72.6000	38.0000	default
	(Reese, et al.)	50.0000	72.6000	38.0000	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4	y = 0.400000 in	M = 0.0000 in-lbs	180000.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Steel H Strong Axis:

Length of Section	=	35.000000 ft
Flange Width	=	14.900000 in
Section Depth	=	14.200000 in
Flange Thickness	=	0.805000 in
Web Thickness	=	0.805000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	34.123950 sq. in.
Moment of Inertia	=	1211. in^4
Elastic Bending Stiffness	=	35125694. kip-in^2
Plastic Modulus, Z	=	192.566083in^3
Plastic Moment Capacity = Fy Z	=	9628.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1706.197 kips
Nominal Axial Tensile Capacity	=	-1706.197 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	180.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 180.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000461	161.9087451	35100995.	46.5334094	6.2151356	
0.00000923	323.8174903	35100995.	26.8167047	7.1553836	
0.00001384	485.7262354	35100995.	20.2444698	8.0956316	
0.00001845	647.6349806	35100995.	16.9583523	9.0358797	
0.00002306	809.5437257	35100995.	14.9866819	9.9761277	

0.00002768	971.4524708	35100995.	13.6722349	10.9163757	
0.00003229	1133.	35100995.	12.7333442	11.8566237	
0.00003690	1295.	35100995.	12.0291762	12.7968718	
0.00004151	1457.	35100995.	11.4814899	13.7371198	
0.00004613	1619.	35100995.	11.0433409	14.6773678	
0.00005074	1781.	35100995.	10.6848554	15.6176159	
0.00005535	1943.	35100995.	10.3861174	16.5578639	
0.00005996	2105.	35100995.	10.1333392	17.4981119	
0.00006458	2267.	35100995.	9.9166721	18.4383599	
0.00006919	2429.	35100995.	9.7288940	19.3786080	
0.00007380	2591.	35100995.	9.5645881	20.3188560	
0.00007842	2752.	35100995.	9.4196123	21.2591040	
0.00008303	2914.	35100995.	9.2907450	22.1993520	
0.00008764	3076.	35100995.	9.1754426	23.1396001	
0.00009225	3238.	35100995.	9.0716705	24.0798481	
0.00009687	3400.	35100995.	8.9777814	25.0200961	
0.0001015	3562.	35100995.	8.8924277	25.9603441	
0.0001061	3724.	35100995.	8.8144961	26.9005922	
0.0001107	3886.	35100995.	8.7430587	27.8408402	
0.0001153	4048.	35100995.	8.6773364	28.7810882	
0.0001199	4210.	35100995.	8.6166696	29.7213362	
0.0001245	4372.	35100995.	8.5604966	30.6615843	
0.0001292	4533.	35100995.	8.5083360	31.6018323	
0.0001338	4695.	35100995.	8.4597727	32.5420803	
0.0001384	4857.	35100995.	8.4144470	33.4823283	
0.0001430	5019.	35100995.	8.3720455	34.4225764	
0.0001476	5181.	35100995.	8.3322940	35.3628244	
0.0001522	5343.	35100995.	8.2949518	36.3030724	
0.0001568	5505.	35100995.	8.2598062	37.2433204	
0.0001614	5667.	35100995.	8.2266688	38.1835685	
0.0001661	5829.	35100995.	8.1953725	39.1238165	
0.0001707	5991.	35100995.	8.1657678	40.0640645	
0.0001753	6153.	35100995.	8.1377213	41.0043125	
0.0001799	6314.	35100995.	8.1111131	41.9445606	
0.0001891	6638.	35100995.	8.0617905	43.8250566	
0.0001983	6962.	35100995.	8.0170560	45.7055527	
0.0002076	7286.	35100995.	7.9762980	47.5860487	
0.0002168	7610.	35100995.	7.9390087	49.4665448	
0.0002260	7904.	34969263.	7.9238050	50.0000000	Y
0.0002352	8120.	34516192.	7.9589877	50.0000000	Y
0.0002445	8236.	33690223.	8.0541460	50.0000000	Y
0.0002537	8330.	32836263.	8.1562682	50.0000000	Y
0.0002629	8418.	32015351.	8.2556890	50.0000000	Y
0.0002721	8499.	31227833.	8.3522036	50.0000000	Y
0.0002814	8574.	30472169.	8.4459146	50.0000000	Y

0.0002906	8644.	29746962.	8.5369034	50.0000000	Y
0.0002998	8710.	29050934.	8.6252336	50.0000000	Y
0.0003090	8772.	28382907.	8.7109528	50.0000000	Y
0.0003183	8829.	27741791.	8.7940948	50.0000000	Y
0.0003275	8884.	27126272.	8.8747434	50.0000000	Y
0.0003367	8932.	26525366.	8.9464583	50.0000000	Y
0.0003459	8977.	25947782.	9.0150017	50.0000000	Y
0.0003552	9016.	25384537.	9.0748055	50.0000000	Y
0.0003644	9053.	24842471.	9.1317845	50.0000000	Y
0.0003736	9085.	24314983.	9.1804104	50.0000000	Y
0.0003829	9114.	23806130.	9.2253945	50.0000000	Y
0.0003921	9140.	23310990.	9.2624600	50.0000000	Y
0.0004013	9162.	22831408.	9.2942738	50.0000000	Y
0.0004105	9181.	22363442.	9.3167440	50.0000000	Y
0.0004198	9196.	21908489.	9.3319767	50.0000000	Y
0.0004290	9207.	21462998.	9.3357841	50.0000000	Y
0.0004382	9216.	21031764.	9.3362901	50.0000000	Y
0.0004474	9225.	20617026.	9.3358424	50.0000000	Y
0.0004567	9233.	20217943.	9.3361421	50.0000000	Y
0.0004659	9240.	19833684.	9.3359388	50.0000000	Y
0.0004751	9247.	19463432.	9.3361020	50.0000000	Y
0.0004843	9254.	19106474.	9.3359250	50.0000000	Y
0.0004936	9260.	18762105.	9.3361689	50.0000000	Y
0.0005028	9266.	18429712.	9.3358009	50.0000000	Y
0.0005120	9272.	18108682.	9.3363442	50.0000000	Y
0.0005212	9277.	17798405.	9.3357186	50.0000000	Y
0.0005305	9282.	17498370.	9.3361978	50.0000000	Y
0.0005397	9287.	17208133.	9.3360220	50.0000000	Y
0.0005489	9291.	16927263.	9.3358286	50.0000000	Y
0.0005858	9308.	15888597.	9.3364121	50.0000000	Y
0.0006227	9321.	14968446.	9.3360220	50.0000000	Y
0.0006596	9332.	14148019.	9.3358499	50.0000000	Y
0.0006965	9342.	13412027.	9.3358894	50.0000000	Y
0.0007334	9350.	12748204.	9.3361421	50.0000000	Y
0.0007703	9357.	12146570.	9.3365596	50.0000000	Y
0.0008072	9363.	11598684.	9.3359250	50.0000000	Y
0.0008441	9368.	11097845.	9.3357448	50.0000000	Y
0.0008810	9372.	10638259.	9.3365861	50.0000000	Y
0.0009179	9377.	10215008.	9.3353951	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	180.0000000000	9377.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	11.6800	0.00	N.A.	No	0.00	1493.
2	13.7000	1.8942	Yes	No	1493.	16743.
3	18.2000	5.1745	Yes	No	18236.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.400000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 180000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.4000	0.00	2369.	-0.00237	5275.	3.51E+10	0.00	0.00	0.00
0.3500	0.3900	11743.	2369.	-0.00237	5347.	3.51E+10	0.00	0.00	0.00
0.7000	0.3801	23485.	2369.	-0.00237	5419.	3.51E+10	0.00	0.00	0.00
1.0500	0.3701	35225.	2369.	-0.00237	5492.	3.51E+10	0.00	0.00	0.00
1.4000	0.3602	46962.	2369.	-0.00236	5564.	3.51E+10	0.00	0.00	0.00
1.7500	0.3503	58694.	2369.	-0.00236	5636.	3.51E+10	0.00	0.00	0.00
2.1000	0.3404	70422.	2369.	-0.00235	5708.	3.51E+10	0.00	0.00	0.00
2.4500	0.3306	82142.	2369.	-0.00234	5780.	3.51E+10	0.00	0.00	0.00
2.8000	0.3207	93856.	2369.	-0.00233	5852.	3.51E+10	0.00	0.00	0.00
3.1500	0.3110	105561.	2369.	-0.00232	5924.	3.51E+10	0.00	0.00	0.00
3.5000	0.3013	117256.	2369.	-0.00230	5996.	3.51E+10	0.00	0.00	0.00
3.8500	0.2916	128941.	2369.	-0.00229	6068.	3.51E+10	0.00	0.00	0.00
4.2000	0.2821	140614.	2369.	-0.00227	6140.	3.51E+10	0.00	0.00	0.00
4.5500	0.2726	152274.	2369.	-0.00225	6211.	3.51E+10	0.00	0.00	0.00
4.9000	0.2631	163921.	2369.	-0.00224	6283.	3.51E+10	0.00	0.00	0.00
5.2500	0.2538	175553.	2369.	-0.00222	6355.	3.51E+10	0.00	0.00	0.00
5.6000	0.2445	187168.	2369.	-0.00219	6426.	3.51E+10	0.00	0.00	0.00
5.9500	0.2353	198767.	2369.	-0.00217	6497.	3.51E+10	0.00	0.00	0.00
6.3000	0.2263	210348.	2369.	-0.00215	6569.	3.51E+10	0.00	0.00	0.00
6.6500	0.2173	221910.	2369.	-0.00212	6640.	3.51E+10	0.00	0.00	0.00
7.0000	0.2085	233452.	2369.	-0.00209	6711.	3.51E+10	0.00	0.00	0.00
7.3500	0.1997	244973.	2369.	-0.00206	6782.	3.51E+10	0.00	0.00	0.00
7.7000	0.1911	256471.	2369.	-0.00203	6852.	3.51E+10	0.00	0.00	0.00
8.0500	0.1826	267947.	2369.	-0.00200	6923.	3.51E+10	0.00	0.00	0.00
8.4000	0.1743	279398.	2369.	-0.00197	6993.	3.51E+10	0.00	0.00	0.00
8.7500	0.1661	290824.	2369.	-0.00194	7064.	3.51E+10	0.00	0.00	0.00
9.1000	0.1580	302223.	2369.	-0.00190	7134.	3.51E+10	0.00	0.00	0.00
9.4500	0.1501	313596.	2369.	-0.00186	7204.	3.51E+10	0.00	0.00	0.00

9.8000	0.1424	324939.	2369.	-0.00183	7274.	3.51E+10	0.00	0.00	0.00
10.1500	0.1348	336254.	2369.	-0.00179	7343.	3.51E+10	0.00	0.00	0.00
10.5000	0.1274	347538.	2369.	-0.00175	7413.	3.51E+10	0.00	0.00	0.00
10.8500	0.1201	358791.	2369.	-0.00170	7482.	3.51E+10	0.00	0.00	0.00
11.2000	0.1131	370011.	2369.	-0.00166	7551.	3.51E+10	0.00	0.00	0.00
11.5500	0.1062	381197.	2369.	-0.00161	7620.	3.51E+10	0.00	0.00	0.00
11.9000	0.09950	392350.	2354.	-0.00157	7688.	3.51E+10	-6.8150	287.6784	0.00
12.2500	0.09301	403346.	2301.	-0.00152	7756.	3.51E+10	-18.4120	831.4298	0.00
12.6000	0.08672	413981.	2199.	-0.00147	7821.	3.51E+10	-30.3328	1469.	0.00
12.9500	0.08065	424044.	2048.	-0.00142	7883.	3.51E+10	-41.6108	2167.	0.00
13.3000	0.07478	433334.	1855.	-0.00137	7940.	3.51E+10	-50.2195	2821.	0.00
13.6500	0.06913	441700.	1631.	-0.00132	7992.	3.51E+10	-56.4580	3430.	0.00
14.0000	0.06371	449029.	1355.	-0.00126	8037.	3.51E+10	-74.9444	4941.	0.00
14.3500	0.05851	454996.	1025.	-0.00121	8073.	3.51E+10	-82.0870	5892.	0.00
14.7000	0.05354	459473.	669.2369	-0.00116	8101.	3.51E+10	-87.5387	6867.	0.00
15.0500	0.04880	462365.	296.9608	-0.00110	8119.	3.51E+10	-89.7356	7723.	0.00
15.4000	0.04429	463632.	-77.2392	-0.00105	8127.	3.51E+10	-88.4548	8388.	0.00
15.7500	0.04002	463297.	-443.2335	-9.90E-04	8125.	3.51E+10	-85.8282	9008.	0.00
16.1000	0.03598	461406.	-794.5830	-9.35E-04	8113.	3.51E+10	-81.4811	9512.	0.00
16.4500	0.03217	458036.	-1121.	-8.80E-04	8092.	3.51E+10	-74.0727	9671.	0.00
16.8000	0.02859	453317.	-1413.	-8.25E-04	8063.	3.51E+10	-64.9283	9539.	0.00
17.1500	0.02524	447413.	-1687.	-7.71E-04	8027.	3.51E+10	-65.2406	10857.	0.00
17.5000	0.02211	440317.	-1959.	-7.18E-04	7983.	3.51E+10	-64.5016	12252.	0.00
17.8500	0.01921	432043.	-2226.	-6.66E-04	7932.	3.51E+10	-62.7222	13717.	0.00
18.2000	0.01652	422624.	-2527.	-6.15E-04	7874.	3.51E+10	-80.3758	20438.	0.00
18.5500	0.01404	411749.	-2860.	-5.65E-04	7807.	3.51E+10	-78.4666	23471.	0.00
18.9000	0.01177	399452.	-3182.	-5.16E-04	7732.	3.51E+10	-74.9740	26749.	0.00
19.2500	0.00970	385797.	-3487.	-4.69E-04	7648.	3.51E+10	-70.1834	30376.	0.00
19.6000	0.00783	370869.	-3778.	-4.24E-04	7556.	3.51E+10	-68.3529	36666.	0.00
19.9500	0.00614	354702.	-4058.	-3.81E-04	7457.	3.51E+10	-65.1022	44520.	0.00
20.3000	0.00463	337354.	-4316.	-3.39E-04	7350.	3.51E+10	-57.5112	52147.	0.00
20.6500	0.00329	318961.	-4526.	-3.00E-04	7237.	3.51E+10	-42.5316	54265.	0.00
21.0000	0.00211	299789.	-4675.	-2.63E-04	7119.	3.51E+10	-28.3527	56382.	0.00
21.3500	0.00108	280089.	-4766.	-2.28E-04	6998.	3.51E+10	-15.0826	58499.	0.00
21.7000	1.94E-04	260099.	-4804.	-1.96E-04	6875.	3.51E+10	-2.8063	60617.	0.00
22.0500	-5.63E-04	240035.	-4792.	-1.66E-04	6751.	3.51E+10	8.4133	62734.	0.00
22.4000	-0.00120	220098.	-4735.	-1.39E-04	6629.	3.51E+10	18.5343	64851.	0.00
22.7500	-0.00173	200468.	-4639.	-1.13E-04	6508.	3.51E+10	27.5339	66969.	0.00
23.1000	-0.00215	181306.	-4506.	-9.05E-05	6390.	3.51E+10	35.4072	69086.	0.00
23.4500	-0.00249	162751.	-4343.	-6.99E-05	6276.	3.51E+10	42.1650	71204.	0.00
23.8000	-0.00274	144926.	-4154.	-5.15E-05	6166.	3.51E+10	47.8324	73321.	0.00
24.1500	-0.00292	127932.	-3944.	-3.52E-05	6062.	3.51E+10	52.4464	75438.	0.00
24.5000	-0.00304	111851.	-3716.	-2.09E-05	5963.	3.51E+10	56.0548	77556.	0.00
24.8500	-0.00310	96748.	-3475.	-8.37E-06	5870.	3.51E+10	58.7135	79673.	0.00
25.2000	-0.00311	82673.	-3225.	2.36E-06	5783.	3.51E+10	60.4853	81790.	0.00

25.5500	-0.00308	69657.	-2969.	1.15E-05	5703.	3.51E+10	61.4381	83908.	0.00
25.9000	-0.00301	57719.	-2710.	1.91E-05	5630.	3.51E+10	61.6429	86025.	0.00
26.2500	-0.00291	46863.	-2452.	2.54E-05	5563.	3.51E+10	61.1727	88142.	0.00
26.6000	-0.00280	37081.	-2198.	3.04E-05	5503.	3.51E+10	60.1009	90260.	0.00
26.9500	-0.00266	28357.	-1949.	3.43E-05	5449.	3.51E+10	58.5001	92377.	0.00
27.3000	-0.00251	20662.	-1707.	3.72E-05	5402.	3.51E+10	56.4406	94494.	0.00
27.6500	-0.00235	13960.	-1475.	3.93E-05	5361.	3.51E+10	53.9898	96612.	0.00
28.0000	-0.00218	8210.	-1254.	4.06E-05	5325.	3.51E+10	51.2113	98729.	0.00
28.3500	-0.00201	3362.	-1046.	4.13E-05	5296.	3.51E+10	48.1638	100846.	0.00
28.7000	-0.00183	-636.0972	-850.2271	4.15E-05	5279.	3.51E+10	44.9008	102964.	0.00
29.0500	-0.00166	-3842.	-668.8485	4.12E-05	5299.	3.51E+10	41.4700	105081.	0.00
29.4000	-0.00149	-6317.	-502.1443	4.06E-05	5314.	3.51E+10	37.9130	107199.	0.00
29.7500	-0.00132	-8122.	-350.5705	3.97E-05	5325.	3.51E+10	34.2651	109316.	0.00
30.1000	-0.00115	-9322.	-214.4481	3.87E-05	5332.	3.51E+10	30.5551	111433.	0.00
30.4500	-9.91E-04	-9982.	-93.9904	3.75E-05	5336.	3.51E+10	26.8057	113551.	0.00
30.8000	-8.36E-04	-10168.	10.6704	3.63E-05	5337.	3.51E+10	23.0328	115668.	0.00
31.1500	-6.86E-04	-9947.	99.4578	3.51E-05	5336.	3.51E+10	19.2469	117785.	0.00
31.5000	-5.41E-04	-9386.	172.3263	3.40E-05	5333.	3.51E+10	15.4524	119903.	0.00
31.8500	-4.01E-04	-8551.	229.2384	3.29E-05	5327.	3.51E+10	11.6487	122020.	0.00
32.2000	-2.65E-04	-7510.	270.1446	3.19E-05	5321.	3.51E+10	7.8305	124137.	0.00
32.5500	-1.33E-04	-6330.	294.9647	3.11E-05	5314.	3.51E+10	3.9886	126255.	0.00
32.9000	-3.62E-06	-5079.	303.5730	3.04E-05	5306.	3.51E+10	0.1106	128372.	0.00
33.2500	1.23E-04	-3826.	295.7870	2.99E-05	5298.	3.51E+10	-3.8182	130489.	0.00
33.6000	2.47E-04	-2640.	271.3596	2.95E-05	5291.	3.51E+10	-7.8139	132607.	0.00
33.9500	3.71E-04	-1591.	229.9759	2.93E-05	5285.	3.51E+10	-11.8926	134724.	0.00
34.3000	4.93E-04	-752.0339	171.2551	2.91E-05	5280.	3.51E+10	-16.0696	136841.	0.00
34.6500	6.15E-04	-196.4720	94.7580	2.91E-05	5276.	3.51E+10	-20.3576	138959.	0.00
35.0000	7.37E-04	0.00	0.00	2.90E-05	5275.	3.51E+10	-24.7653	70538.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.40000000 inches
Computed slope at pile head     =    -0.00237344 radians
Maximum bending moment          =       463632. inch-lbs
Maximum shear force             =         -4804. lbs
Depth of maximum bending moment =    15.40000000 feet below pile head
Depth of maximum shear force    =    21.70000000 feet below pile head
```

Number of iterations = 7
Number of zero deflection points = 2

Summary of Pile-head Responses for Conventional Analyses

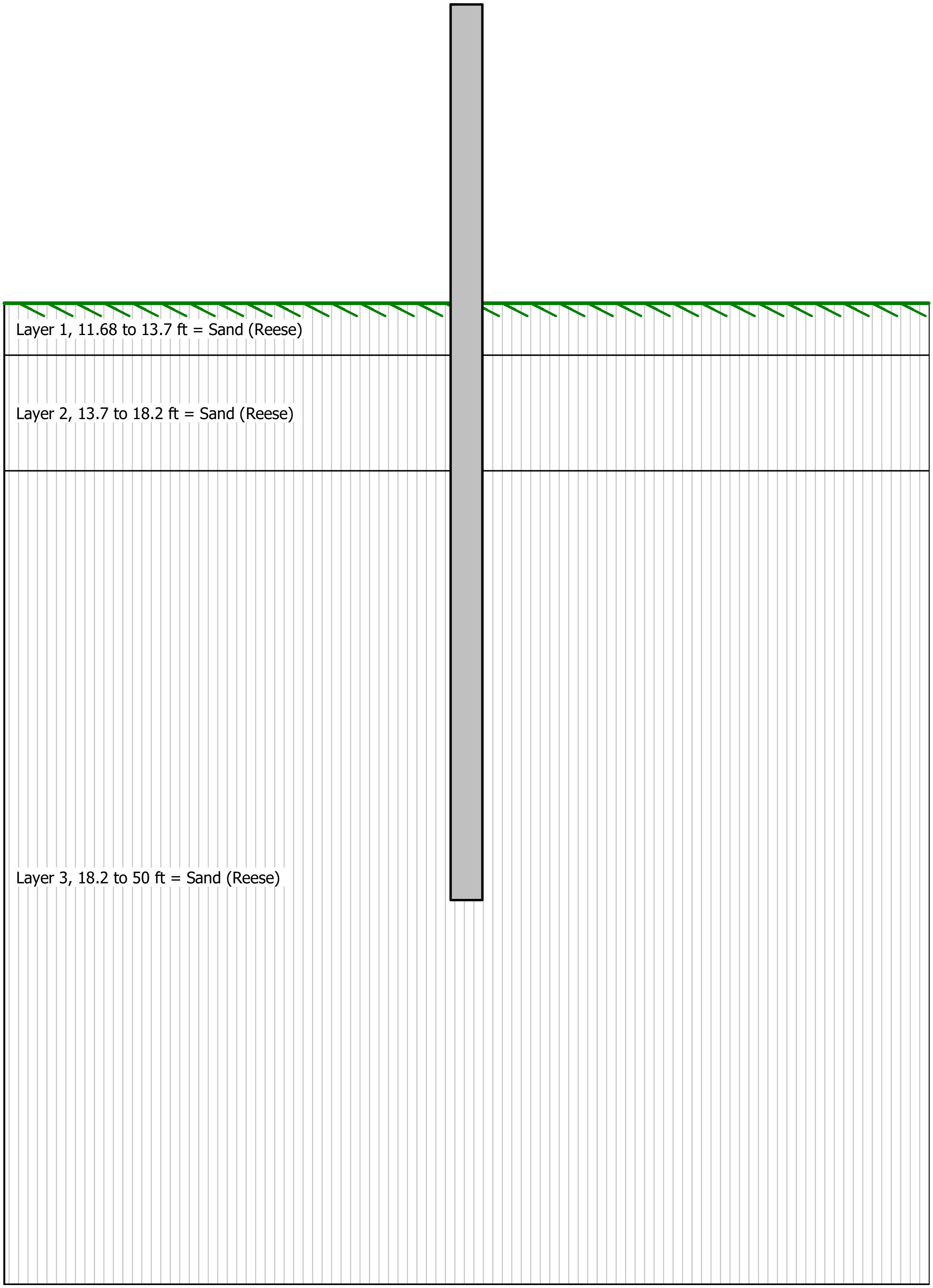
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

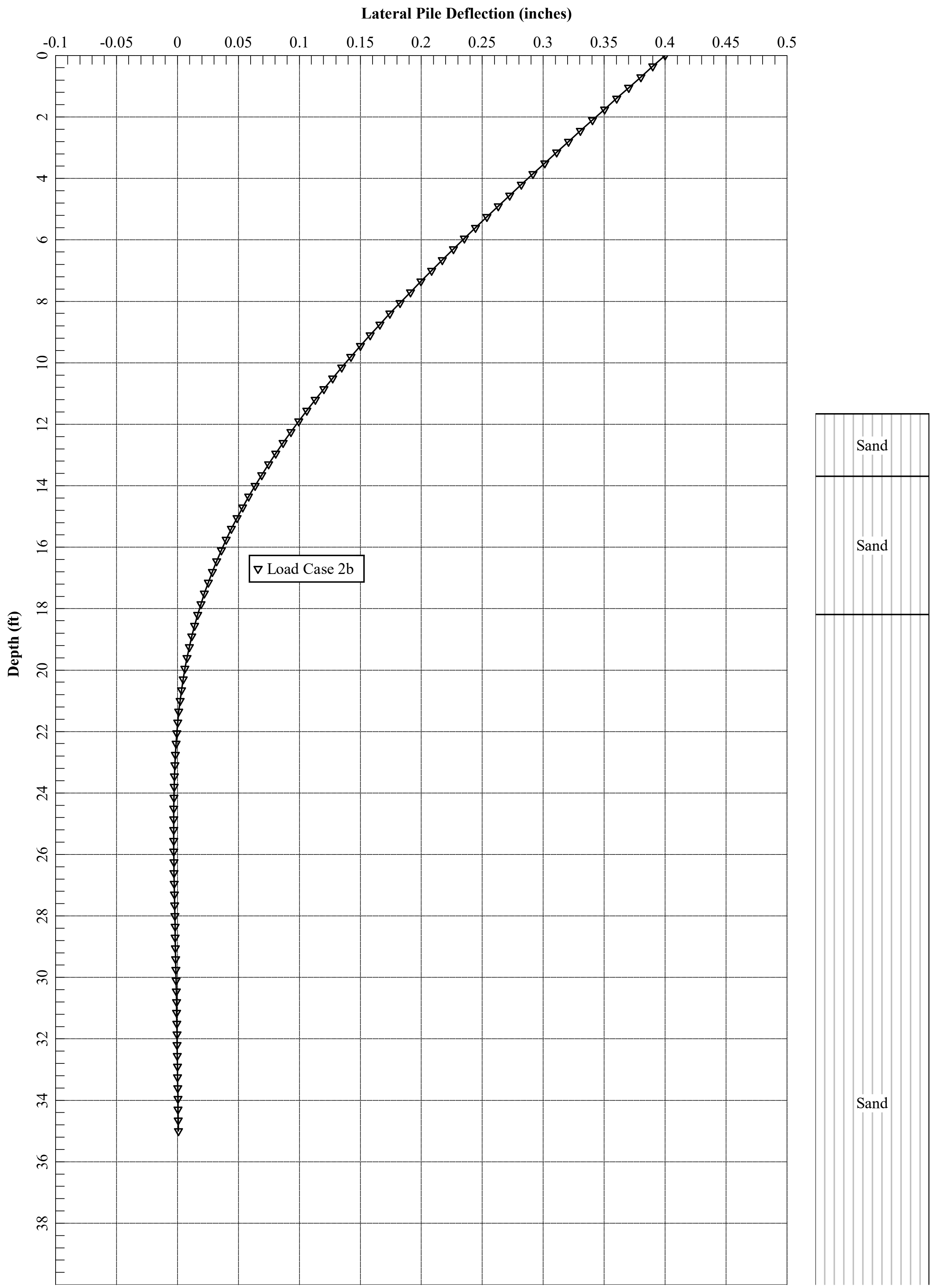
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.4000	M, in-lb	0.00	180000.	0.4000	-0.00237	-4804.	463632.

Maximum pile-head deflection = 0.4000000000 inches
Maximum pile-head rotation = -0.0023734408 radians = -0.135988 deg.

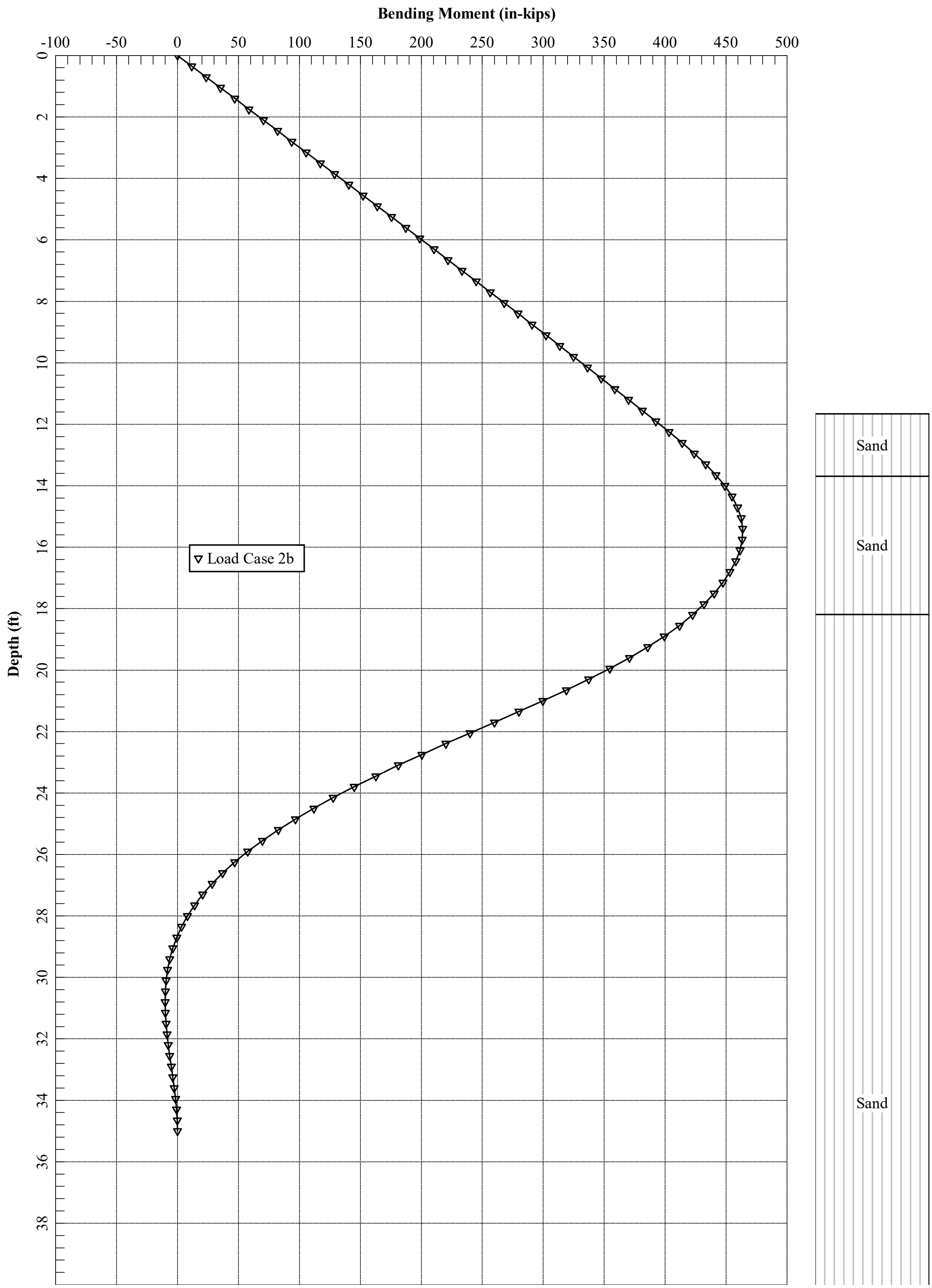
The analysis ended normally.

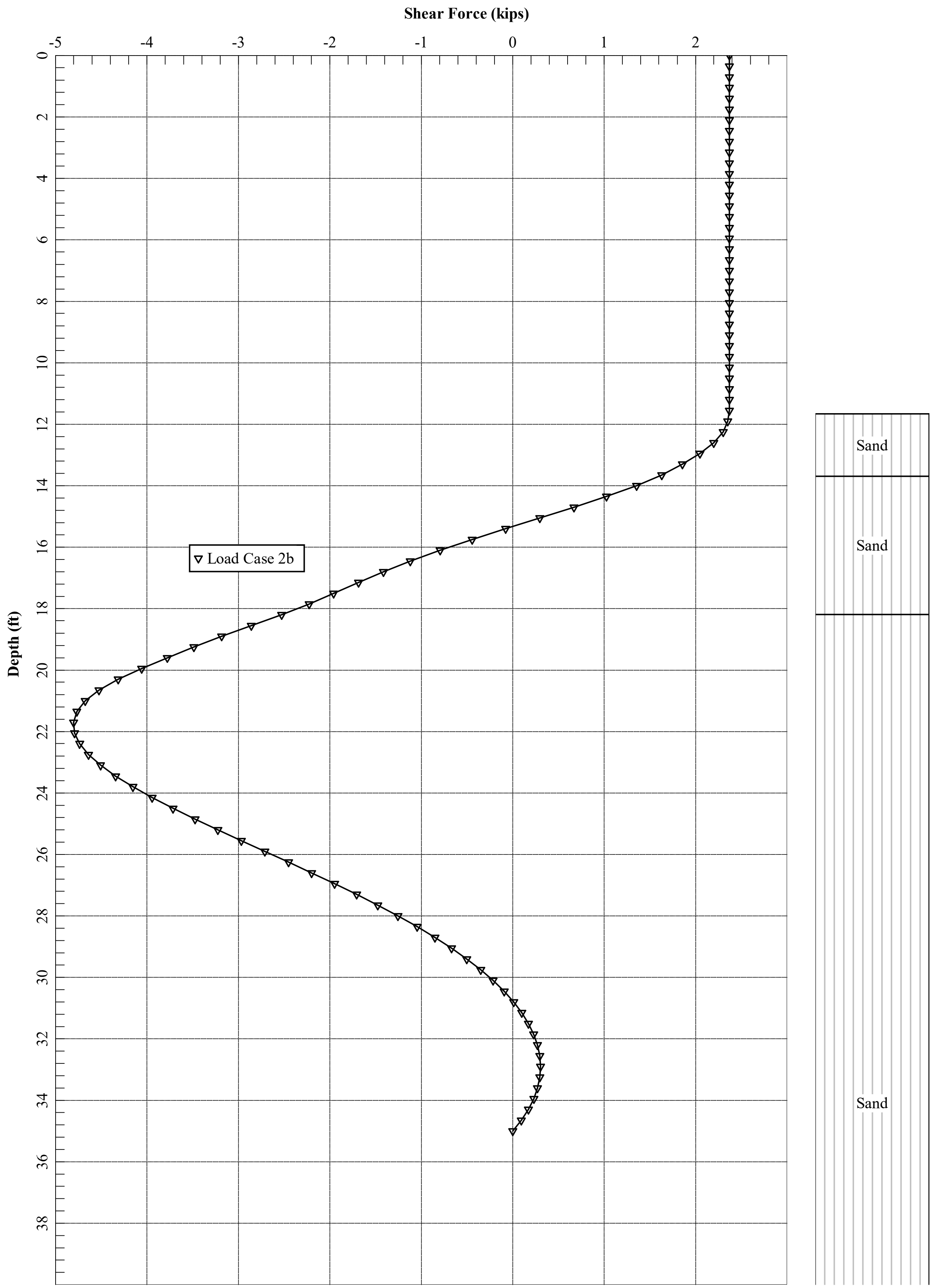


LPile 2018.10.09, © 2018 by Ensoft, Inc.

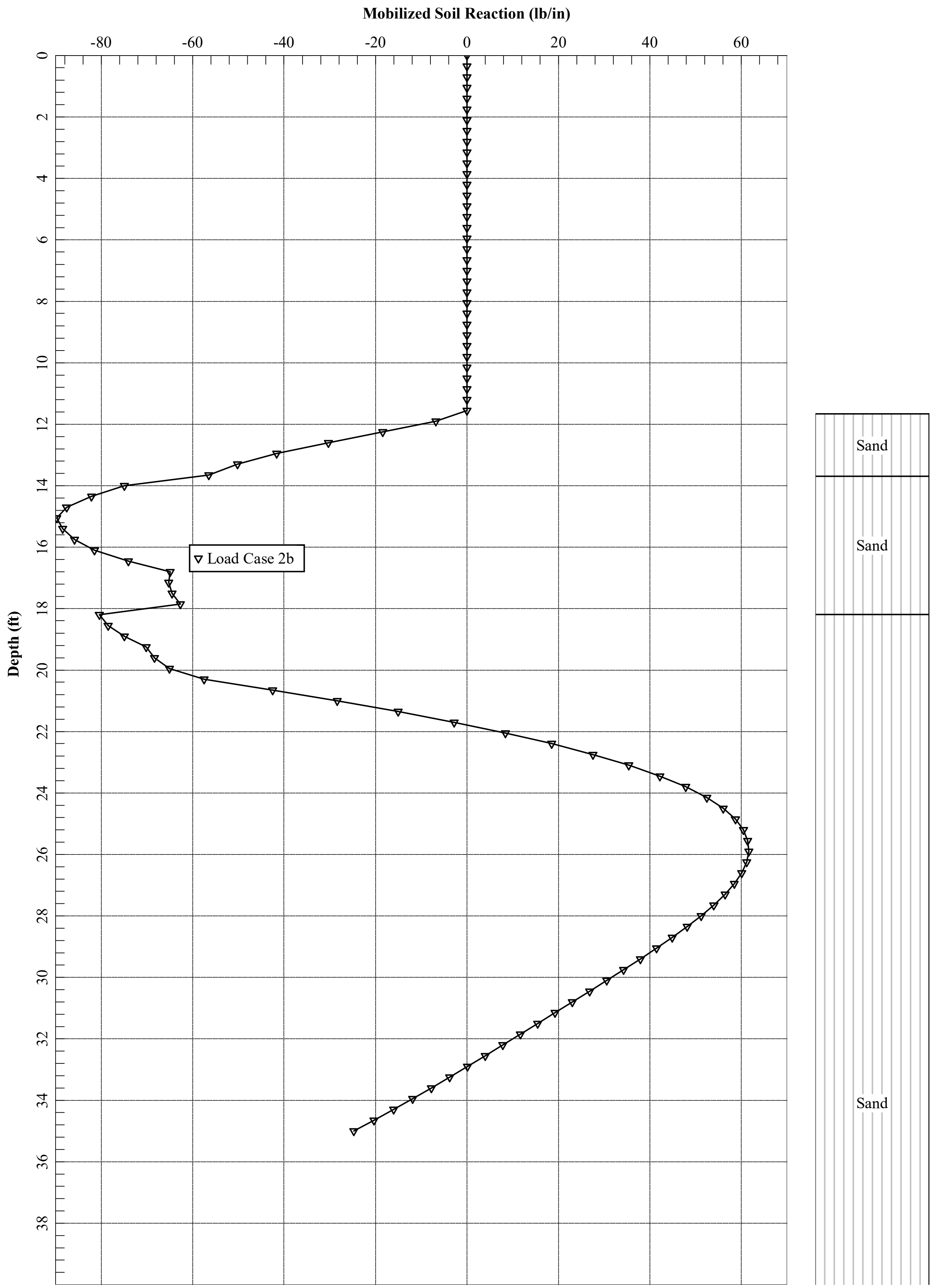


Lateral Pile Deflection (inches)
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2b
Sand
Sand
Sand


Bending Moment (in-kips)
-100
-50
0
50
100
150
200
250
300
350
400
450
500
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2b
Sand
Sand
Sand



Shear Force (kips)
-5
-4
-3
-2
-1
0
1
2
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2b
Sand
Sand
Sand


Mobilized Soil Reaction (lb/in)
-80
-60
-40
-20
0
20
40
60
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Load Case 2b
Sand
Sand
Sand

BR. 79.81 GEOTECHNICAL REPORT
(BR. 79.90 = BR. 79.81 IN REPORT)

Consulting
Engineers and
Scientists

March 31, 2020
Project 1703257

VIA EMAIL: June.Wu@hdrinc.com

Ms. June Wu, P.E.
HDR Engineering, Inc.
99 High Street, Suite 2300
Boston, Massachusetts 02110

Dear Ms. Wu:

Re: Geotechnical Recommendations for Bridge Replacement
Berkshire Line Bridge - Mile Post 79.90
Lenox, Massachusetts

This letter report presents the results of our subsurface explorations and our geotechnical recommendations for the replacement of the Massachusetts Department of Transportation (MassDOT) Berkshire Line Bridge at Mile Post 79.90 in Lenox, Massachusetts.

We performed the following scope of work:

- Performed one boring at the north bridge abutment.
- Performed one boring at the south bridge abutment.
- Performed one boring at the midspan of the bridge.
- Submitted soil samples collected from the river bottom soil to a laboratory for grain size analyses to support a scour analysis, which was performed by others.
- Evaluated the subsurface conditions and developed basic soil properties and recommendations for replacement of the existing bridge.
- Prepared this letter report presenting the results of our subsurface explorations, our analyses, and our recommendations.

We performed this work under the Subconsultant Agreement between HDR Engineering, Inc. and GEI Consultants, Inc., dated August 1, 2017 and Amendment #2 to the Subconsultant Agreement, dated September 10, 2018. Our scope of work is based on our proposal dated July 10, 2018.

Elevations in this report are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88). Boring depths are referenced to the top of the existing train rail near each boring location, at approximately El. 953.7.

GEI Consultants, Inc.
400 Unicorn Park Drive, Woburn, MA 01801
781.721.4000 fax: 781.721.4073

Site and Project Description

The MassDOT Berkshire Line Railroad Bridge at Mile Post 79.90 crosses Willow Creek to the west of Roaring Brook Road and the Housatonic River and north of Willow Creek Road in Lenox, Massachusetts (Fig. 1). The existing bridge is a three-span timber trestle bridge, about 25 feet long, with timber beams supporting an open timber deck. The bridge beams and deck are supported by four timber bents (Pier 1 to 4, south to north). Each of the bridge abutments consists of a timber backwall and wingwalls located behind Pier 1 and 4, as shown in Fig. 2.

We understand that the existing three-span bridge is experiencing distress and that the bridge substructure will be replaced to accommodate a wider bridge deck for a new two-span bridge. The existing timber beams, piles, backwalls, and wingwalls will be removed and the proposed substructure for the new bridge will consist of a precast concrete pier cap at midspan and precast concrete abutments, all supported on pile foundations. In addition, steel sheet piling is proposed to be installed in front of the north and south abutments and along the east and west sides of the embankments to retain the embankment fill behind the abutments.

Subsurface Explorations

Borings

Aquifer Drilling and Testing, Inc. of Mineola, New York, drilled three borings (B401 through B403) from October 2, 2018 to October 9, 2018. The boring locations are shown in Fig. 2. The boring logs are provided in Appendix A. A GEI engineer was on site full time to coordinate the work and log the borings.

The borings were drilled using a CME hi-rail mounted truck drill rig and advanced using wash-rotary techniques with flush jointed casing. The borings were performed along the centerline of the tracks about 3 feet behind the north abutment (B401), 3 feet behind the south abutment (B402), and at midspan (B403). Standard Penetration Tests (SPTs) were performed using an automatic hammer, and bedrock was cored in B402 using an NX-size core barrel.

B401 was advanced to a depth of about 90 feet below the top of rail and terminated in glacial till after reaching refusal possibly on bedrock. B402 was terminated at a depth of 98 feet below the top of rail after coring 10 feet of bedrock. B403 was advanced to a depth of 32 feet below the top of rail and terminated in silt and sand. The streambed was approximately 6 feet below the top of rail at midspan of the bridge and the water level in the creek at the time of the borings was about 3.3 feet below the top of rail. Bedrock was not encountered in B401 or B403.

Laboratory Testing

We submitted four split spoon soil samples from B403 to GeoTesting Express of Acton, Massachusetts to evaluate soil gradation to support a scour analysis performed by others. Results of the grain size analyses are provided in Appendix B.

Subsurface Conditions

The soil layers encountered in the borings are described below, in order of increasing depth. A simplified subsurface profile is shown in Fig. 3. Subsurface conditions are known only at sample locations, and may differ significantly from those shown in Fig. 3 and described below. These variations may not become evident until construction.

- Fill – An approximately 5- to 6-foot-thick layer of fill was encountered at the ground surface in B401 and B402 behind the abutments. The top of the fill layer consisted of ballast between 6 inches and 1 foot thick. Below the ballast, the fill generally consisted of sand and gravel with approximately 5 to 15 percent non-plastic fines. The SPT N-values ranged from 8 to 20 blows per foot (bpf), indicating a loose to medium dense soil. Timber was encountered in the fill layer in B402.

- Gravel – A thin (approximately 3-foot-thick) layer of gravel was encountered at the mudline in B403. The gravel layer consisted of mostly fine to coarse gravel with approximately 15 to 33 percent sand and 11 to 25 percent non-plastic fines. The SPT N-value was 3 bpf, indicating a very loose soil.

- Silt and Sand – A layer of silt and sand was encountered beneath the gravel in B403 and the beneath the fill in B401 and B402. The silt and sand layer generally consisted of non-plastic to low plasticity fines with varying amounts of fine to medium sand, fine to medium sand with silt, and silty sand. The thickness of the silt and sand layer was approximately 68 feet in B401 and 56 feet in B402. The SPT N-values ranged from 2 to 56 bpf indicating a very loose to dense soil. Wood fibers and timber were encountered in the silt and sand layer in B402 between depths of about 15 feet and 30 feet.

- Glacial Outwash – Glacial outwash was encountered beneath the silt and sand layer in B401 and B402 at approximate depths of 62 to 73 feet below top of rail, corresponding to El. 892 to El. 881. In B401, the glacial outwash consisted of mostly fine to coarse sand with about 10 percent non-plastic fines. In B402, the glacial outwash consisted of mostly fine sand with about 35 to 45 percent non-plastic fines. The thickness of the glacial outwash layer was approximately 10 feet in B401 and 13 feet in B402. The SPT N-values ranged from 10 to 77 bpf indicating a loose to very dense soil.

- Glacial Till – Glacial till was encountered beneath the glacial outwash layer in B401 and B402 at approximate depths of 75 to 83 feet below top of rail, corresponding to El. 879 to El. 871. The glacial till consisted of mostly fine to coarse gravel with about 10 to 50 percent fine to coarse sand and 5 to 20 percent non-plastic to low plastic fines. The thickness of the glacial till was approximately 7 feet in B401 and 13 feet in B402. The SPT-N values ranged from 61 to 166 bpf indicating a very dense soil.

- Bedrock – Hard, moderately fractured, dolomitic marble bedrock was encountered approximately 88 feet below top of rail (approximately El. 866) in B402. Refusal on likely bedrock was encountered approximately 90 feet below top of rail (approximately El. 864) in B401.

Water Levels

The river level during the subsurface exploration was measured at approximately El. 950.4, which was 3.3 feet below the top of rail. The river and groundwater levels may vary significantly at other times. Groundwater levels are expected to vary with river levels.

The 100-year flood elevations for the existing and proposed conditions at the bridge are El. 953.69 and El. 953.91, respectively (HDR, 2019).

Soil Properties

Recommended soil properties for analysis and design are presented below. We estimated these values based on published correlations to SPT N-values and visual soil and rock descriptions.

Stratum	Friction Angle, Φ (deg)	Unit Weight, lb/ft^3	K_a	K_0	K_p
Fill	30	125	0.33	0.50	3.0
Silt and Sand	32	120	0.31	0.47	4.5
Glacial Outwash	35	130	0.27	0.43	5.3
Glacial Till	38	135	0.24	0.38	6.6

Seismic Design Information

We recommend the following seismic design criteria based on the AREMA 2016 Manual for Railway Engineering (AREMA, 2016) and the 2014 United States Geological Society Hazard Mapping Data. Based on the boring data, we recommend using Site Class D (AREMA Chapter 9, Part 1, Section 1.4.4.1.1).

Base Acceleration Coefficients (AREMA Section 1.3.2.3)	
475-Year Return Period	**2,475-Year Return Period**
PGA_{475}=0.034	PGA_{2475}=0.084
$S_{S,475}$=0.070	$S_{S,2475}$=0.160
$S_{1,475}$=0.020	$S_{1,2475}$=0.047

Site Factors (AREMA Section 1.4.4.1.2)	
475-Year Return Period	**2,475-Year Return Period**
$F_{PGA-475}$=1.6	$F_{PGA-2475}$=1.6
F_{a-475}=1.6	F_{a-2475}=1.6
F_{v-475}=2.4	F_{v-2475}=2.4

Based on the borings and our review of the soil samples collected in the borings, it is our opinion that the site soils are not susceptible to earthquake-induced liquefaction during the design earthquake. There were some low SPT N-values in the silt and sand below the water table. We performed liquefaction triggering analyses in borings B401, B402, and B403 using the Idriss and Boulanger (2008) methodology. The factors of safety against liquefaction were all greater than 1.5.

Recommendations

Abutment and Pier Foundation Recommendations

We recommend supporting the new pier and abutments on driven or drilled piles. We understand that the construction will be sequenced to minimize disruption to weekday service and will take

place during non-train operation hours or foul time. The demolition of the existing bridge and foundations, construction of precast concrete bridge abutments, precast concrete pier cap, and the superstructure will also be sequenced to take place on a weekend shutdown to avoid interruption of train operations.

We understand the maximum vertical loads at the abutments and pier are approximately 370 and 500 kips, respectively. The maximum lateral loads at the abutments and pier are approximately 150 and 110 kips, respectively.

Driven Piles

For the driven pile option, we recommend that the piles be driven to refusal in the glacial outwash or glacial till or on bedrock. Based on the loads above and our lateral analyses, we recommend evaluating an HP14x117 for the driven piles.

Due to the potential for pile damage during driving from cobbles and boulders in the fill and glacial till layers, we recommend specifying HP14x117 piles with high strength cast steel tip reinforcement such as Associated Pile & Fitting's Hard-Bite Points. Given their small cross-sectional area, we anticipate that the piles will reach refusal on bedrock.

To verify axial capacity and the pile driving criteria, we recommend that the piles be monitored during driving using the Pile Driving Analyzer (PDA) with signal matching. We recommend specifying an ultimate vertical capacity of 2.25 times the maximum working load (using allowable stress design load combinations) for pile resistances verified using PDA testing. We recommend PDA testing be performed on at least one abutment pile on each side, one battered pier pile, and one vertical pier pile for a total of at least 4 piles.

The piles will also be subjected to lateral loads due to lateral soil pressure on the abutments, lateral soil pressure from the railroad surcharge, and longitudinal bridge forces. We understand the structure will be detailed to allow either the north or south abutments to be engaged based on the direction of loading. Our lateral load analyses for a typical abutment and the pier are provided in Appendix C. To provide adequate lateral load resistance, we recommend advancing the piles a minimum of 50 feet below the bottom of the pile caps (highest allowable tip elevation of approximately El. 898) and orienting for the piles for strong axis bending. However, we expect the piles will penetrate deeper into the glacial outwash or glacial till or to the top of bedrock to develop the required axial capacity.

Assuming that the piles are driven to top of bedrock, the vertical pile lengths are estimated to be about 82 to 84 feet measured from the bottom of the pile caps (about El. 948) to the top of bedrock (about El. 864 to 866).

We recommend designing the piles with an 1/8-inch corrosion allowance. The bottom of the proposed pile caps will be below the normal high-water level in the river. To reduce the potential for pile corrosion, we recommend coating the piles with coal tar epoxy before driving. The coal tar epoxy coating should extend at least 15 feet below the stream bed.

Drilled Piles

For the drilled pile option, we recommend using micropiles. Based on our preliminary analysis, if the abutments and pier are each supported on three piles (similar to the H-pile option), we recommend using 16-inch-O.D. piles with a 0.5-inch-thick wall. Smaller diameter micropiles (9.625- and 10.75-inch-O.D.) are more common but additional piles would be required to support the abutments and pier to meet the deformation criteria required by AREMA.

The piles would develop their vertical capacity through side friction in the glacial outwash and glacial till. For preliminary design, we recommend an allowable bond stress of 10 psi and 20 psi in the glacial outwash and glacial till, respectively. If the thickness of glacial outwash and glacial till is not sufficient to develop the required vertical capacity, the bond zone may be extended into bedrock. We recommend using an allowable bond stress of 75 psi in the bedrock.

The piles will also be subjected to lateral loads due to lateral soil pressure on the abutments, lateral soil pressure from the railroad surcharge, and longitudinal bridge forces. We understand the structure will be detailed to allow either the north or south abutments to be engaged based on the direction of loading. Our lateral load analyses for a typical abutment and the pier are provided in Appendix C. To provide adequate lateral load resistance, we recommend that the steel casing extend a minimum of 50 feet below the bottom of the pile caps (highest allowable bottom of casing elevation of approximately El. 898). We recommend considering the location of the micropile joints in the design of the piles since the joints will have a reduced section and strength.

AREMA does not provide specific guidance on the structural design of micropiles. Therefore, we recommend that the structural design of the micropiles be performed in accordance with the latest edition of the Massachusetts State Building Code. We recommend that the final design of the micropile bond length be designed by the specialty geotechnical contractor. We also recommend that a pile load test be performed on a sacrificial pile to 2.0 times the design load to verify the geotechnical design of the pile. If the test pile is not installed in the general vicinity of the bridge, we recommend performing a construction-phase boring near the proposed test pile to verify the soil conditions are consistent with those encountered near the bridge.

Sheet Pile Recommendations

We understand that sheet piles will be installed to retain the embankment fill and to prevent soil loss from behind the abutments due to scour, as discussed below. AREMA does not recommend cantilever sheet pile walls for permanent applications due to the large deformations required to mobilize full passive resistance. However, based on our understanding of the existing conditions and the site grades, it is our opinion that a cantilever sheet pile wall is feasible for this project if: 1) the approach slab is supported on the abutment and the approach slab is designed to span from the abutment to about 2 to 3 feet from the other end of the approach slab, 2) sheet pile wall deformations up to about 1 inch are acceptable after the design scour event, and 3) relatively small settlements (less than 3/4 inch) at the crest of the embankment are acceptable after the design scour event. If these are not suitable, we recommend a braced sheet pile wall supported with tie rods.

Based on the geometry provided in the 60% design drawings transmitted to us on February 20, 2020, we understand the top of the sheet piles will be at approximately El. 950 in front of the abutment and El. 949 at the toe of the embankment for the return walls. We assumed the top of the embankment would be at El. 954 and the back face of the sheet pile return walls will be at least 17.5 feet from the centerline of rail. We assumed the embankment fill is free draining and

the water level will be equal on both sides of the sheet piles. We estimated the current elevation of the river bottom to be El. 946 and we assumed the post scour elevation in front of the wall will be El. 938. We recommend driving the sheet piles to El. 917 to achieve adequate toe embedment for a cantilever sheet pile. We recommend designing the sheet piles with 1/8-inch corrosion allowance. If additional corrosion protection is desired, we recommend specifying coal tar epoxy coating on the sheet piles.

For our evaluation, we assumed A572 Grade 50, PZ 35 sheet piles. The computed deformation, bending moment, and shear for a typical north-south section and east-west section are provided in Appendix D. The sheet pile walls were analyzed using the average active earth pressure computed using a Coulomb wedge analysis considering the proposed embankment geometry and the railroad surcharge.

Scour

Based on HDR's scour analysis, the soil around the proposed pier at midspan and in front of the proposed abutments is susceptible to scour during a flood event. HDR performed a scour analysis for the pier and abutments based on the grain size data provided in Appendix B (HDR, 2019). The results of the scour analysis indicated that the 100-year flood scour depths would be 6.7 feet at the abutments and 5.78 feet at the pier. The existing river bottom elevation varies but is generally about El. 946.

As discussed above, sheet pile walls will be installed in front of the abutments, which will prevent scour below the abutments. If scour protection is not provided for the center pier, the pier piles should be checked for buckling under full scour conditions.

Construction Considerations

Excavations for the abutments may require temporary excavation support and dewatering. To the extent possible, excavations should be maintained as shallow as possible to reduce the need for dewatering. Any necessary excavation support system should be designed in conjunction with a dewatering system by a Massachusetts-registered professional engineer experienced in excavation support and dewatering system design. The engineer should be engaged by the contractor and submit their designs for review before installation. All excavations should be made in accordance with OSHA standards.

Groundwater will likely be encountered during the excavation for the abutments. The specifications should require the contractor to maintain the groundwater level below the bottom of the excavation at all times. We recommend that the excavation subgrade be sloped slightly to a sump. Sumps should be located outside the limits of the proposed pile cap and should extend at least 2 feet below the bottom of the excavation. Deeper sumps or closely spaced well points may be required to draw down the groundwater to maintain stability of the subgrades during subgrade preparation. The contractor should submit a dewatering plan prior to the start of excavation. We expect permits will be required for the proposed work.

Our borings indicated the presence of timber in the fill and silt and sand layers and possible cobbles and boulders in the glacial till layer that could affect driving the piles to the required depths, and to the required vertical / horizontal tolerances. The timber may be remnants from earlier deep foundation elements. Pre-augering, spudding, or removal of any near-surface obstructions may be necessary before driving the piles.

If driven piles are used, we recommend monitoring the existing structure for movement and potential damage during pile driving. Temporary support of the existing spans may be necessary to protect the existing structure during pile driving. Temporary support of the existing structure should be designed by a Massachusetts-registered professional engineer engaged by the Contractor and designs should be submitted to the Engineer for review. During pile driving, we recommend that daily inspections of all connections and critical members of the existing bridge be performed by a professional engineer engaged by the Contractor.

Backfilling under the precast abutments will be difficult. Special consideration will need to be made to minimize loose soil below the abutment because compaction equipment will not fit under the structure. Therefore, we recommend considering using lean concrete or flowable fill to backfill up to 6 inches above the underside of the precast abutment. This will improve lateral performance of the structure and provide additional corrosion protection at the top of the abutment piles.

Soil placed as fill should be free of frost. The area behind the abutments should be backfilled with Gravel Borrow (MassDOT M1.03.0 Type B) or onsite soils that meet the Gravel Borrow Specifications. Backfill should be placed in maximum 12-inch thick loose lifts. Each lift should be compacted to at least 95 percent of the soil's maximum dry density per ASTM D698 at a moisture content within 2 percent of optimum.

Limitations

This letter was prepared for the use of HDR Engineering, Inc., exclusively. Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed structure. We cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design. We also recommend that GEI observe and document the installation of the piles.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report. We, therefore, recommend that GEI be engaged to make site visits during construction to: a) check that the subsurface conditions exposed during construction are in general conformance with our design assumptions and b) ascertain that, in general, the work is being performed in compliance with the contract documents.

Our professional services for this project have been performed in accordance with generally accepted engineering practices; no warranty, express or implied, is made.

If you have any questions, please feel free to contact James Christensen at 781-721-4126 or Darren Clark at 207-797-8910.

Sincerely,

GEI CONSULTANTS, INC.

James L. Christensen, P.E.
Project Manager

Darren D. Clark, P.E. (ME)
Project Manager

JRG/JLC/DDC:bdp
Attachments
- Fig. 1 – Site Location Map
- Fig. 2 – Boring Location Plan
- Fig. 3 – Subsurface Profile A - A'
- Appendix A – Boring Logs
- Appendix B – Laboratory Test Results
- Appendix C – H-Pile and Micropile Lateral Analysis
- Appendix D – Sheet Pile Analysis Results

References

AREMA (2016). AREMA Railway Manual, Manual for Railway Engineering.

FHWA (2005). "NHI Course No. 132078, Micropile Design and Construction, Reference Manual," Publication No. FHWA NHI-05-039, December.

HDR (2019). "Determination of Scour at Bridge 79.90, Housatonic River Railroad over Willow Creek," prepared for Massachusetts Department of Transportation – Rail and Transit Division, November 13.

Idriss, I.M., and Boulanger, R.W. (2008). "Soil Liquefaction during Earthquakes," EERI Monograph Series, MNO-12.

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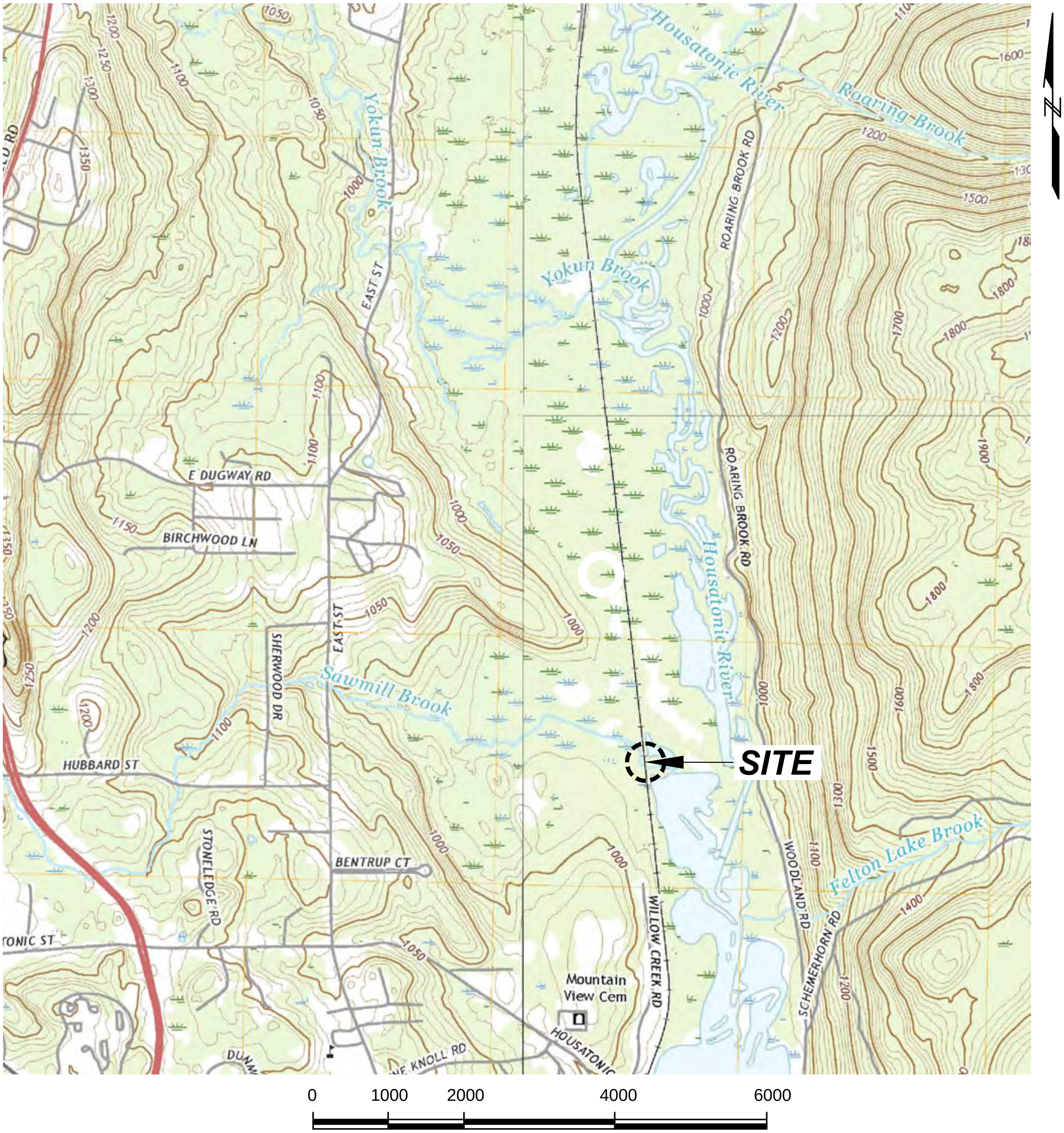
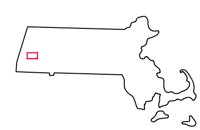
Figures



This Image from U.S.G.S. Topographic 7.5 Minute Series
Pittsfield East, MA Quadrangle, 2018.
Datum is North American Vertical Datum of 1988 (NAVD88).
Contour Interval is 20 Feet.



MassDOT Berkshire Line Bridge MP 79.90 Lenox, Massachusetts	GEI Consultants	SITE LOCATION MAP
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020 Fig. 1

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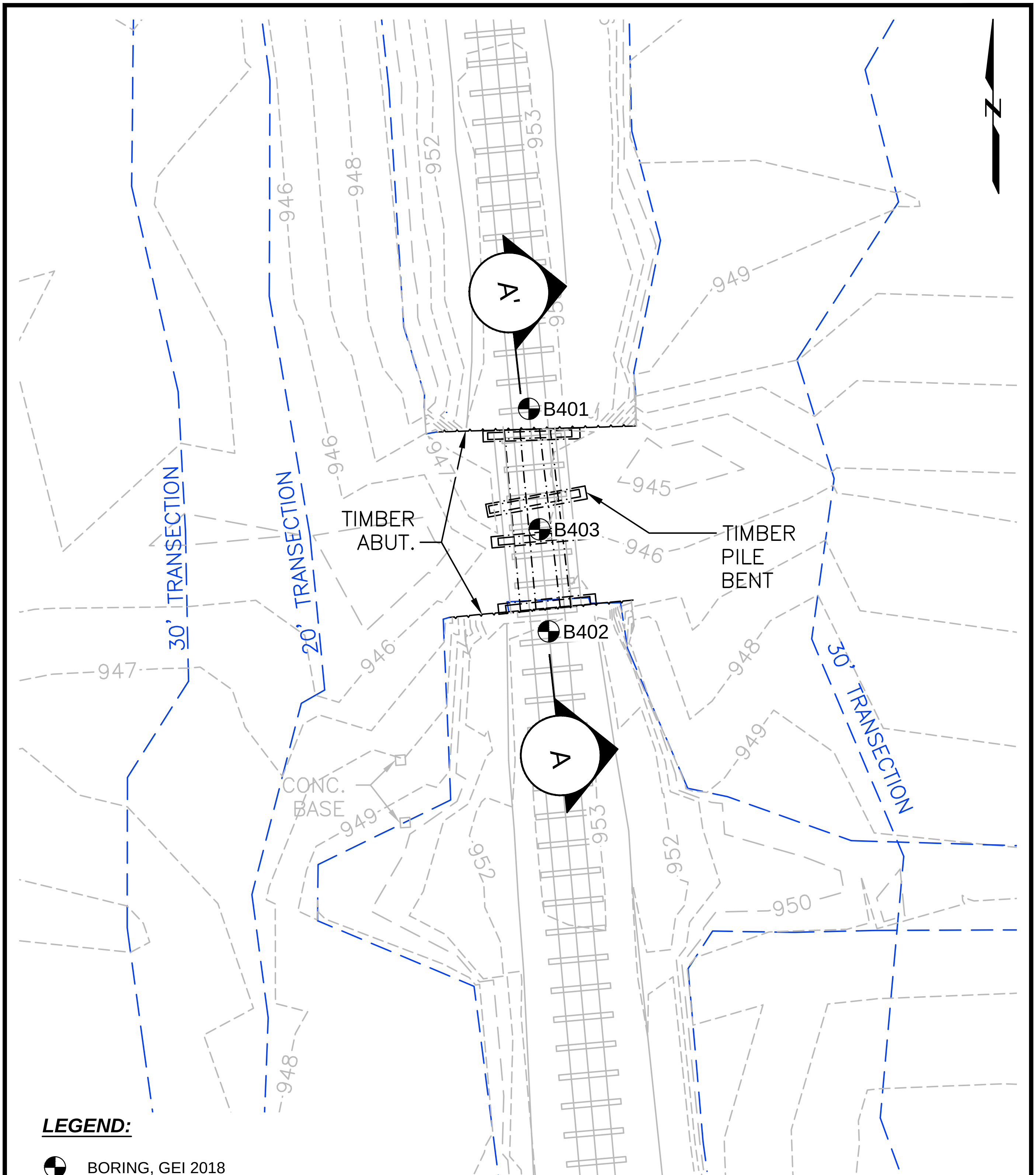


LEGEND:

BORING, GEI 2018

NOTES:

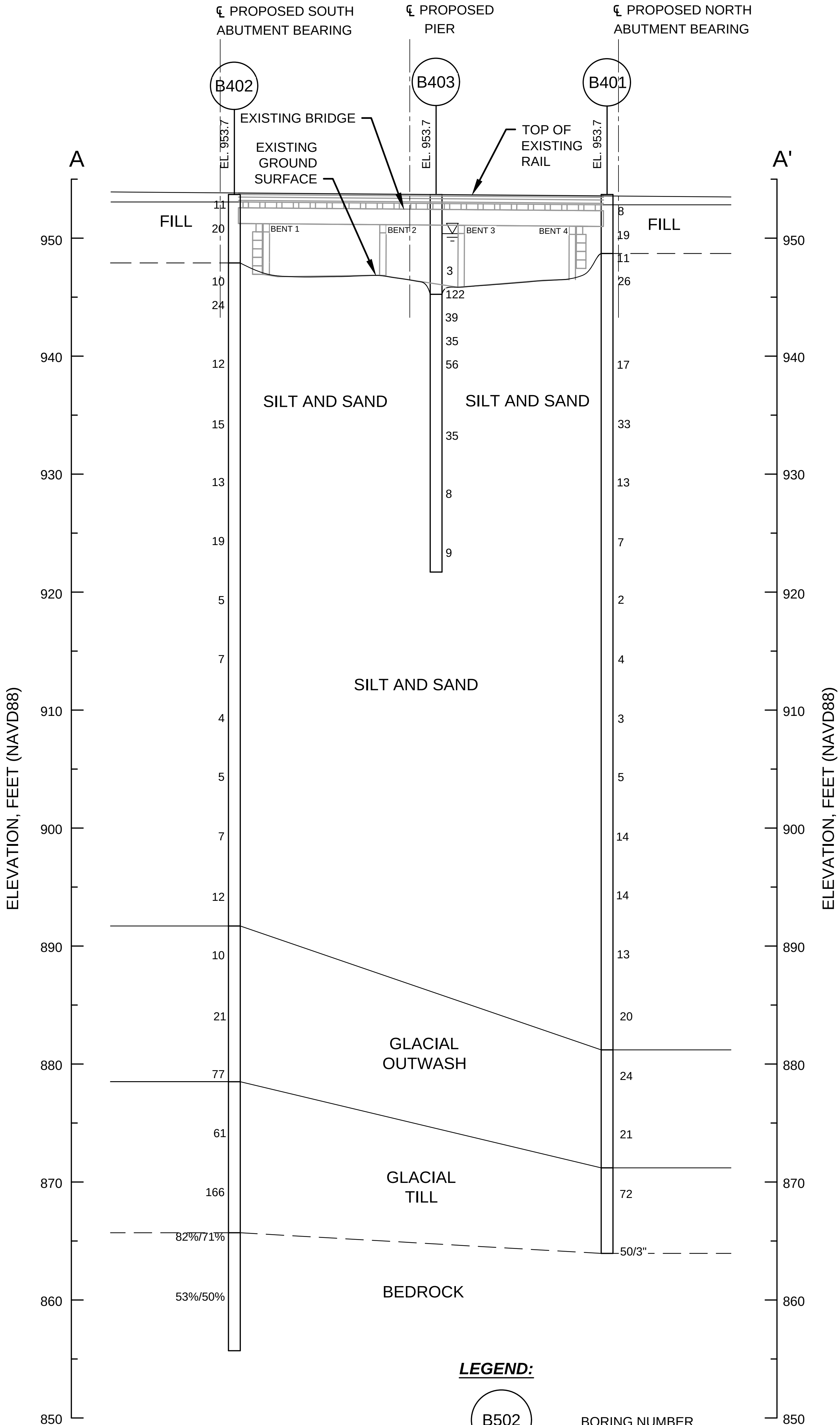
1. BASE PLAN FROM PRELIMINARY SURVEY DRAWING FROM C&C CONSULTING ENGINEERS, LLC DATED NOVEMBER 21, 2018.

0 20 40

SCALE: 1" = 20'

MassDOT Berkshire Line Bridge MP 79.90 Lenox, Massachusetts	GEI Consultants	BORING LOCATION PLAN
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020 Fig. 2

\\geiconsulta B:\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\00_CAD\Figures\Br 79.90 Subsurface Program\1703257-02_BR 79-90 (LENOX) BLP.dwg - 12/4/2019



LEGEND:

B502 — BORING NUMBER

EL. 919.2 — ELEVATION OF GROUND SURFACE

EXISTING GROUND SURFACE

WATER LEVEL IN CREEK ON 10/9/2018

STRATUM BOUNDARY

107 — N-VALUE FROM STANDARD PENETRATION TEST, BLOWS PER FOOT

93%/40% — ROCK CORE RECOVERY/ROCK QUALITY DESIGNATION (RQD)

NOTES

1. PROFILE AND BORING LOCATIONS ARE SHOWN IN FIG. 2.
2. THE BOUNDARIES BETWEEN SOIL STRATA MAY BE TRANSITIONAL. THE STRATA BOUNDARIES BETWEEN BORINGS MAY VARY SIGNIFICANTLY FROM THE INTERPOLATIONS SHOWN.

0 10 20

SCALE: 1" = 10'

MassDOT Berkshire Line Bridge MP 79.90 Lenox, Massachusetts	GEI Consultants	SUBSURFACE PROFILE A - A'	
HDR Engineering, Inc. Boston, Massachusetts	Project 1703257	March 2020	Fig. 3

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Appendix A

Boring Logs

BORING INFORMATION

LOCATION: Bridge 79.90, North Abutment

GROUND SURFACE EL. (ft): 953.7

DATE START/END: 10/2/2018 - 10/3/2018

VERTICAL DATUM: NAVD 88

DRILLING COMPANY: Aquifer Drilling and Testing, Inc.

TOTAL DEPTH (ft): 89.8

DRILLER NAME: Tim Van Ness

LOGGED BY: D. Litton

RIG TYPE: CME Hi-Rail Mounted Truck Rig

BORING B401

DRILLING INFORMATION

HAMMER TYPE: Automatic

CASING I.D./O.D.: 4 inch / 4.5 inch

CORE BARREL TYPE: NA

AUGER I.D./O.D.: NA / NA

DRILL ROD O.D.: 2.675 inch

CORE BARREL I.D./O.D. NA / NA

DRILLING METHOD: Driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): Not measured

ABBREVIATIONS:

Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer

S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger

Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I.D./O.D. = Inside Diameter/Outside Diameter

NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample Information: Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
							SAND AND GRAVEL	(0-1'): BALLAST.
		S1	1 to 3	24/7	8-4-4-4		SAND AND GRAVEL	S1: SILTY SAND WITH GRAVEL (SM); ~60% fine to coarse sand, ~25% fine to coarse gravel, ~15% non-plastic fines; brown to black; wet. <FILL>
950		S2	3 to 5	24/2	4-8-11-9		SAND AND GRAVEL	S2: SANDY LEAN CLAY (CL); ~60% low plastic fines, ~30% fine to medium sand; gray with black; wet. <FILL>
	5	S3	5 to 7	24/13	7-6-5-8		SILT AND SAND	S3: SILT WITH SAND (ML); ~65% non-plastic fines, ~25% fine sand; gray; wet.
		S4	7 to 9	24/14	12-12-14-14		SILT AND SAND	S4: SILT WITH SAND (ML); Similar to S3.
945	10					~10 ft, mix bentonite clay. Rig chatter ~11 ft.	SILT AND SAND	
940	15	S5	14 to 16	24/16	12-11-6-4		SILT AND SAND	S5: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic to low plastic fines; tan; wet.
935	20	S6	19 to 21	24/14	12-16-17-15		SILT AND SAND	S6: SILTY SAND (SM); Similar to S5.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90

CITY/STATE: Lenox, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, North Abutment		BORING B401
GROUND SURFACE EL. (ft): 953.7	DATE START/END: 10/2/2018 - 10/3/2018	
VERTICAL DATUM: NAVD 88	DRILLING COMPANY: Aquifer Drilling and Testing, Inc.	PAGE 2 of 4

Elev. (ft)	Depth (ft)	Sample Information: Sample No.	Sample Information: Depth (ft)	Sample Information: Pen./Rec. (in)	Sample Information: Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	24 to 26	24/15	6-6-7-10		SILT AND SAND	S7: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic to low plastic fines; light brown; moist.
925	30	S8	29 to 31	24/15	4-3-4-5			S8: SANDY SILT (ML); ~65% non-plastic fines; ~35% fine sand; gray; wet. Liquifies with vibration / shaking.
920	35	S9	34 to 36	24/21	3/12"-1-1			S9: SANDY SILT (ML); Similar to S8.
915	40	S10	39 to 41	24/18	2-1-3-3			S10: SILTY SAND (SM); ~70% fine to medium sand, ~30% non-plastic fines; gray; wet.
910	45	S11	44 to 46	24/18	1-2-1/12"			S11: SILTY SAND (SM); ~60% fine sand, ~40% non-plastic fines; gray; wet.
905	50	S12	49 to 51	24/18	3-2-3-3			S12: SILT WITH SAND (ML); ~60% non-plastic to low plastic fines, ~40% fine sand; tan and gray; wet.
900	55	S13	54 to 56	24/12	3-6-8-7			S13: SILTY SAND (SM); ~80% fine to medium sand, ~20% non-plastic fines; tan; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90

CITY/STATE: Lenox, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	60	S14	59 to 61	24/11	4-7-7-10		SILT AND SAND	S14: SILTY SAND (SM); ~65% fine sand, ~35% non-plastic fines; tan; wet.
890	65	S15	64 to 66	24/14	WOH-6-7-8		SILT AND SAND	S15: SILTY SAND (SM); Similar to S14, except gray with tan bands.
885	70	S16	69 to 71	24/9	8-10-10-14		SILT AND SAND	S16: SILTY SAND (SM); ~85% fine to medium sand, ~15% non-plastic fines; tan; wet.
880	75	S17	74 to 76	24/8	8-11-13-16		GLACIAL OUTWASH	S17: WIDELY GRADED SAND WITH SILT (SW-SM); ~90% fine to coarse sand, 10% non-plastic fines; tan; wet.
875	80	S18	79 to 81	24/13	7-10-11-10		GLACIAL OUTWASH	S18: WIDELY GRADED SAND WITH SILT (SW-SM); Similar to S17.
870	85	S19	84 to 86	24/8	35-42-30-44	Rig chatter ~84 ft.	GLACIAL TILL	S19: WIDELY GRADED GRAVEL WITH SAND AND SILT (GW-GM); ~60% fine to coarse gravel up to 1.5 inch, ~30% fine to coarse sand, ~10% non-plastic to low plastic fines; tan to white; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

LOCATION: Bridge 79.90, North Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/2/2018 - 10/3/2018
DRILLING COMPANY: Aquifer Drilling and Testing, Inc.

BORING B401

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
						Bit grinding between 86 to 89 ft.		
865								
	90	S20	89 to 89.8	9/6	32-50/3"			S20: WIDELY GRADED GRAVEL WITH SAND AND SILT (GW-GM); ~60% fine to coarse gravel up to 1 inch, ~30% fine to coarse sand, ~10% non-plastic to low plastic fines; tan; wet. Till.
								Bottom of boring at depth 89.8 feet. Grout mix: 2 bags (94-lb) portland cement, 1 bag bentonite. Borehole backfilled with tremie grout to existing grade.
860	95							
855	100							
850	105							
845	110							
840	115							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION

LOCATION: Bridge 79.90, South Abutment

GROUND SURFACE EL. (ft): 953.7 **DATE START/END:** 10/4/2018 - 10/8/2018

VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

TOTAL DEPTH (ft): 98.0 **DRILLER NAME:** Tim Van Ness

LOGGED BY: D. Litton **RIG TYPE:** CME Hi-Rail Mounted Truck Rig

BORING B402

DRILLING INFORMATION

HAMMER TYPE: Automatic **CASING I.D./O.D.:** 4 inch / 4.5 inch **CORE BARREL TYPE:** NX

AUGER I.D./O.D.: NA / NA **DRILL ROD O.D.:** 2.675 inch **CORE BARREL I.D./O.D.** 2 inch / 3 inch

DRILLING METHOD: Driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): Not measured

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I.D./O.D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
							SAND AND GRAVEL	(0-6"): BALLAST.
		S1	0.5 to 2.5	24/4	5-6-5-3		SAND AND GRAVEL	S1: WIDELY GRADED SAND WITH GRAVEL (SW); ~50% fine to coarse sand, ~45% fine to coarse gravel, ~5% non-plastic fines; black; moist. <FILL>
950		S2	2.5 to 4.5	24/3	6-8-12-10	Wood in drill wash ~4 ft.	SAND AND GRAVEL	S2: WIDELY GRADED GRAVEL WITH SAND (GW); ~80% fine to coarse gravel, ~15% fine to coarse sand, ~5% non-plastic fines; brown to black; wet. <FILL>
	5					Drill through timber.		
						Drill wash color change ~6 ft.	SILT AND SAND	
945		S3	7 to 9	24/11	4-4-6-7		SILT AND SAND	S3: SILT WITH SAND (ML); ~85% non-plastic fines, 15% fine sand; gray; wet.
	10	S4	9 to 11	24/19	9-13-11-15	Mix mud. Continue open hole.	SILT AND SAND	S4: SILTY SAND (SM); ~70% fine sand, ~30% non-plastic fines; gray; wet.
940	15	S5	14 to 16	24/10	8-9-3-4		SILT AND SAND	S5: SILTY SAND (SM); ~65% fine to medium sand, ~30% non-plastic fines, ~5% fine gravel; brown; wet. Wood fibers.
935	20	S6	19 to 21	24/13	5-9-6-8		SILT AND SAND	S6: SILTY SAND (SM); Similar to S3.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90

CITY/STATE: Lenox, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

GEI WOBURN STD 1-LOCATION-LAYER NAME HOUSATONIC BR 79.90 - 20200117.GPJ 3/31/20

LOCATION: Bridge 79.90, South Abutment		BORING B402
GROUND SURFACE EL. (ft): 953.7	DATE START/END: 10/4/2018 - 10/8/2018	
VERTICAL DATUM: NAVD 88	DRILLING COMPANY: Aquifer Drilling and Testing, Inc.	PAGE 2 of 4

Elev. (ft)	Depth (ft)	Sample Information: Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	24 to 26	24/14	7-7-6-9		SILT AND SAND	S7: SILT WITH SAND (ML); ~85% non-plastic to low plastic fines, ~15% fine sand; gray; wet. ~7 inch timber in spoon. Wood grain parallel to spoon.
925	30	S8	29 to 31	24/18	9-12-7-10			S8: SILTY SAND (SM); ~60% fine to medium sand, ~40% non-plastic fines; tan to gray; wet. Wood fibers.
920	35	S9	34 to 36	24/15	2-2-3-2	Use paint screen to clean timber fibers from tub.		S9: SILT WITH SAND (ML); ~75% non-plastic to low plastic fines, ~25% fine sand; gray with tan seams; wet.
915	40	S10	39 to 41	24/10	3-4-3-3			S10: SANDY SILT (ML); ~60% non-plastic fines, ~40% fine sand; tan; wet.
910	45	S11	44 to 46	24/13	2-2-2-1			S11: SANDY SILT (ML); Similar to S10, except gray.
905	50	S12	49 to 51	24/14	2-2-3-2			S12: LEAN CLAY WITH SAND (CL); ~85% low plastic fines, ~15% fine sand; gray with tan bands.
900	55	S13	54 to 56	24/10	3-3-4-5			S13: SANDY SILT (ML); ~60% non-plastic fines, ~40% fine sand; tan; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, South Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/4/2018 - 10/8/2018
DRILLING COMPANY: Aquifer Drilling and Testing, Inc.

BORING B402

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	60	S14	59 to 61	24/12	3-6-6-10		SILT AND SAND	S14: SILT WITH SAND (ML); ~75% non-plastic fines, ~25% fine sand; gray; wet.
890	65	S15	64 to 66	24/17	4-4-6-10		GLACIAL OUTWASH	S15: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic fines; tan; wet.
885	70	S16	69 to 71	24/8	6-10-11-12		GLACIAL OUTWASH	S16: SILTY SAND (SM); ~65% fine sand, ~35% non-plastic fines; tan; wet.
880	75	S17	74 to 76	24/10	6-32-45-23		GLACIAL OUTWASH	S17 (0-6"): SILTY SAND (SM); Similar to S15.
						Rig chatter from 76 to 79 ft.	GLACIAL TILL	S17 (6"-10"): WIDELY GRADED GRAVEL (GW); ~85% fine to coarse gravel up to 1-inch, ~10% fine to coarse sand, ~5% non-plastic fines; gray; wet.
						Possible boulder ~78 ft.		
875	80	S18	79 to 81	24/15	54-34-27-45		GLACIAL TILL	S18: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM): ~50% fine to coarse sand, ~40% fine to coarse gravel, ~10% non-plastic fines; tan to gray; wet.
						Rig chatter from 81 to 84 ft.		
870	85	S19	84 to 85.8	22/16	45-86-80-100/4"		GLACIAL TILL	S19: SILTY GRAVEL WITH SAND (GM); ~60% fine to coarse gravel, ~20% fine to coarse sand, ~20% non-plastic fines; tan, gray, and white; wet. Rock seam from 8"-10".

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
865		C1	88 to 93	60/49	71	Core times (min/ft): 4, 6, 4, 6, 4	DOLOMITIC MARBLE	C1: DOLOMITIC MARBLE; Hard, joint ~60 degrees at 8" - 10", near horizontal joints at 14", 36", 47", moderately fractured from 5" - 11" , lightly weathered joints. 0 to 5", 14" to 36", and 36" to 47" single piece, white.
	90							
860		C2	93 to 98	60/32	50	Core times (min/ft): 3, 3, 5, 4, 4	DOLOMITIC MARBLE	C2: DOLOMITIC MARBLE; Hard, joints between 10 and 45 degrees at 5", 12", 24", 28", and 30", severely fractured 0-5", lightly weathered joints, light gray to white.
	95							
855								Bottom of boring at depth 98 ft. Borehole backfilled with tremie grout to existing grade.
	100							
850								
	105							
845								
	110							
840								
	115							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION		**BORING B403**
LOCATION: Bridge 79.90, Mid-span		PAGE 1 of 2
GROUND SURFACE EL. (ft): 953.7	**DATE START/END:** 10/9/2018 - 10/9/2018	
VERTICAL DATUM: NAVD 88	**DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.	
TOTAL DEPTH (ft): 32.0	**DRILLER NAME:** Tim Van Ness	
LOGGED BY: D. Litton	**RIG TYPE:** CME Hi-Rail Mounted Truck Rig	

DRILLING INFORMATION

HAMMER TYPE: Automatic **CASING I.D./O.D.:** 4 inch / 4.5 inch **CORE BARREL TYPE:** NA

AUGER I.D./O.D.: NA / NA **DRILL ROD O.D.:** 2.675 inch **CORE BARREL I.D./O.D.** NA / NA

DRILLING METHOD: Spun and driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): ⊻ 3.3 10/9/2018 8:58 am

ABBREVIATIONS: Pen. = Penetration Length; Rec. = Recovery Length; RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%; WOR = Weight of Rods; WOH = Weight of Hammer; S = Split Spoon Sample; C = Core Sample; U = Undisturbed Sample; SC = Sonic Core; DP = Direct Push Sample; HSA = Hollow-Stem Auger; Qp = Pocket Penetrometer Strength; Sv = Pocket Torvane Shear Strength; LL = Liquid Limit; PI = Plasticity Index; PID = Photoionization Detector; I.D./O.D. = Inside Diameter/Outside Diameter; NA, NM = Not Applicable, Not Measured; Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O.D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/Field Test Data	Layer Name	Soil and Rock Description
950	5							
		S1	6 to 8	24/8	1-1-2-8		S & G	S1: WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); 56.6% fine to coarse angular gravel, 32.6% fine to coarse sand, 10.8% non-plastic fines (from grain size analysis); black; wet. 4-inch timber in spoon. <FILL>
945		S2	8 to 10	24/16	34-38-84-33		S & G / SILT AND SAND	S2 (0-6"): SILTY GRAVEL WITH SAND (GM); ~60% fine to coarse gravel, ~25% non-plastic to low plastic fines, ~15% fine to coarse sand; black; wet. S2(6"-16"): SILTY SAND WITH GRAVEL (SM) ~40% fine to coarse sand, ~30% non-plastic fines, ~30% fine to coarse gravel; gray; wet.
	10	S3	10 to 12	24/15	17-19-20-16		SILT AND SAND	S3: SILT (ML); 94.6% non-plastic fines, 5.4% fine sand (from grain size analysis); gray; wet.
		S4	12 to 14	24/11	16-17-18-26		SILT AND SAND	S4: SILT WITH SAND (ML): ~75% non-plastic to low plastic fines, ~20% fine to coarse sand, ~5% fine gravel; gray; wet.
940	15	S5	14 to 16	24/18	20-26-30-33		SILT AND SAND	S5: SANDY SILT (ML); 72.1% non-plastic fines, 27.9% fine sand (from grain size analysis); gray; wet.
935	20						SILT AND SAND	
		S6	20 to 22	24/16	10-17-18-17		SILT AND SAND	S6: SILT (ML); 89.7% non-plastic fines, 10.3% fine sand (from grain size analysis); gray; wet.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018. S1-S3 were taken with a 3-inch split spoon. Debris and organics were resting on top of stream bed.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90

CITY/STATE: Lenox, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, Mid-span
GROUND SURFACE EL. (ft): 953.7 **DATE START/END:** 10/9/2018 - 10/9/2018
VERTICAL DATUM: NAVD 88 **DRILLING COMPANY:** Aquifer Drilling and Testing, Inc.

BORING B403

Elev. (ft)	Depth (ft)	Sample Information: Sample No.	Sample Information: Depth (ft)	Sample Information: Pen./Rec. (in)	Sample Information: Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	25 to 27	24/12	3-3-5-10		SILT AND SAND	S7: SILT (ML); ~90% non-plastic to low plastic fines; ~10% fine sand; gray to tan; wet.
925								
	30	S8	30 to 32	24/20	4-4-5-5			S8: SILT WITH SAND (ML); ~80% non-plastic fines, ~20% fine sand; gray and tan; wet.
								Bottom of boring at depth 32 ft. Borehole backfilled with tremie grout to existing grade.
920								
	35							
915								
	40							
910								
	45							
905								
	50							
900								
	55							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consulting Engineers, LLC dated November 21, 2018. S1-S3 were taken with a 3-inch split spoon. Debris and organics were resting on top of stream bed.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

Appendix B

Laboratory Test Results

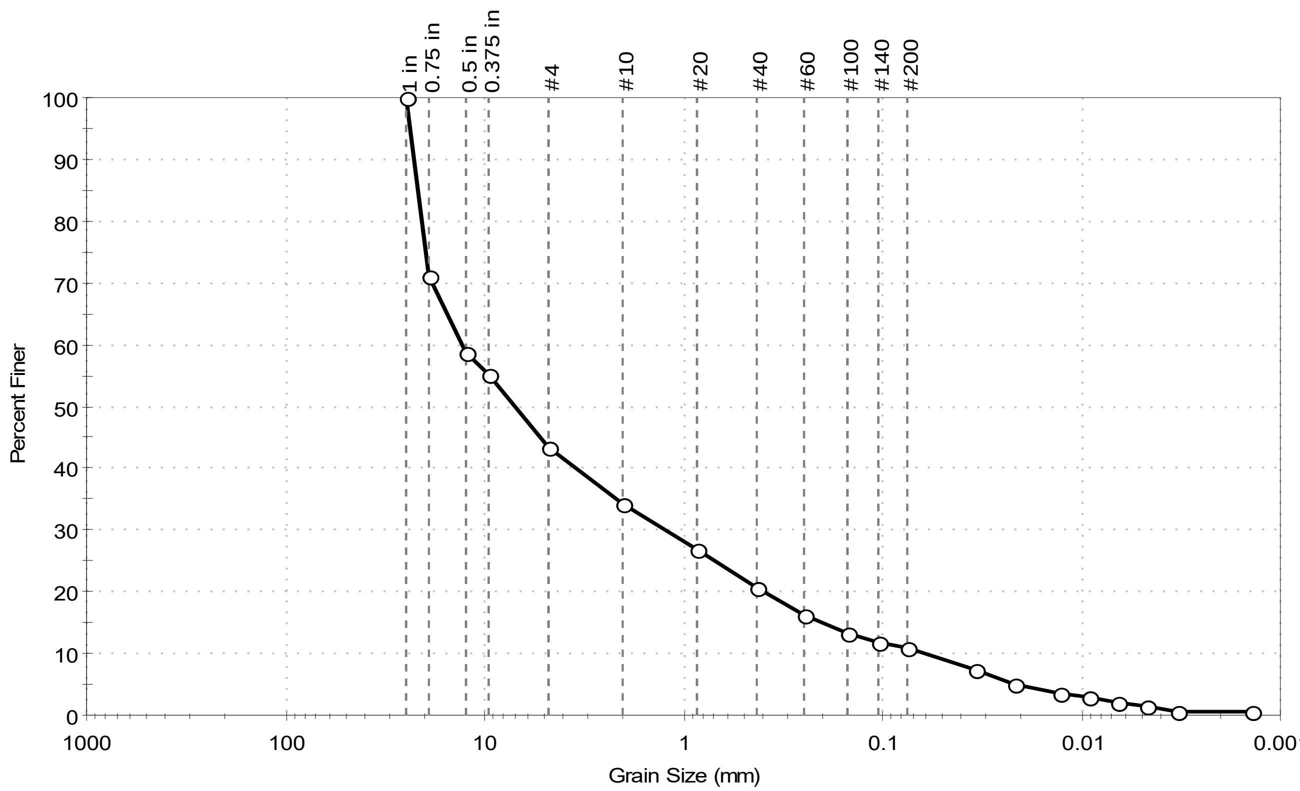
Client:	GEI Consultants, Inc.		
Project:	MassDOT Berkshire Line Bridge 79.90		
Location:	Lenox, MA	Project No:	GTX-310237
Boring ID: B403	Sample Type: jar	Tested By:	ckg
Sample ID: S1	Test Date: 07/11/19	Checked By:	bfs
Depth : 6-8	Test Id: 513031		

Test Comment: ---

Visual Description: Moist, dark olive brown gravel with silt and sand

Sample Comment: ---

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	56.6	32.6	10.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	71		
0.5 in	12.50	59		
0.375 in	9.50	55		
#4	4.75	43		
#10	2.00	34		
#20	0.85	27		
#40	0.42	21		
#60	0.25	16		
#100	0.15	13		
#140	0.11	12		
#200	0.075	11		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0339	7		
---	0.0219	5		
---	0.0130	4		
---	0.0091	3		
---	0.0066	2		
---	0.0047	1		
---	0.0033	1		
---	0.0014	1		

Coefficients

D_{85} = 21.6761 mm	D_{30} = 1.2334 mm
D_{60} = 13.0637 mm	D_{15} = 0.2011 mm
D_{50} = 6.9928 mm	D_{10} = 0.0627 mm
C_u = 208.352	C_c = 1.857

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

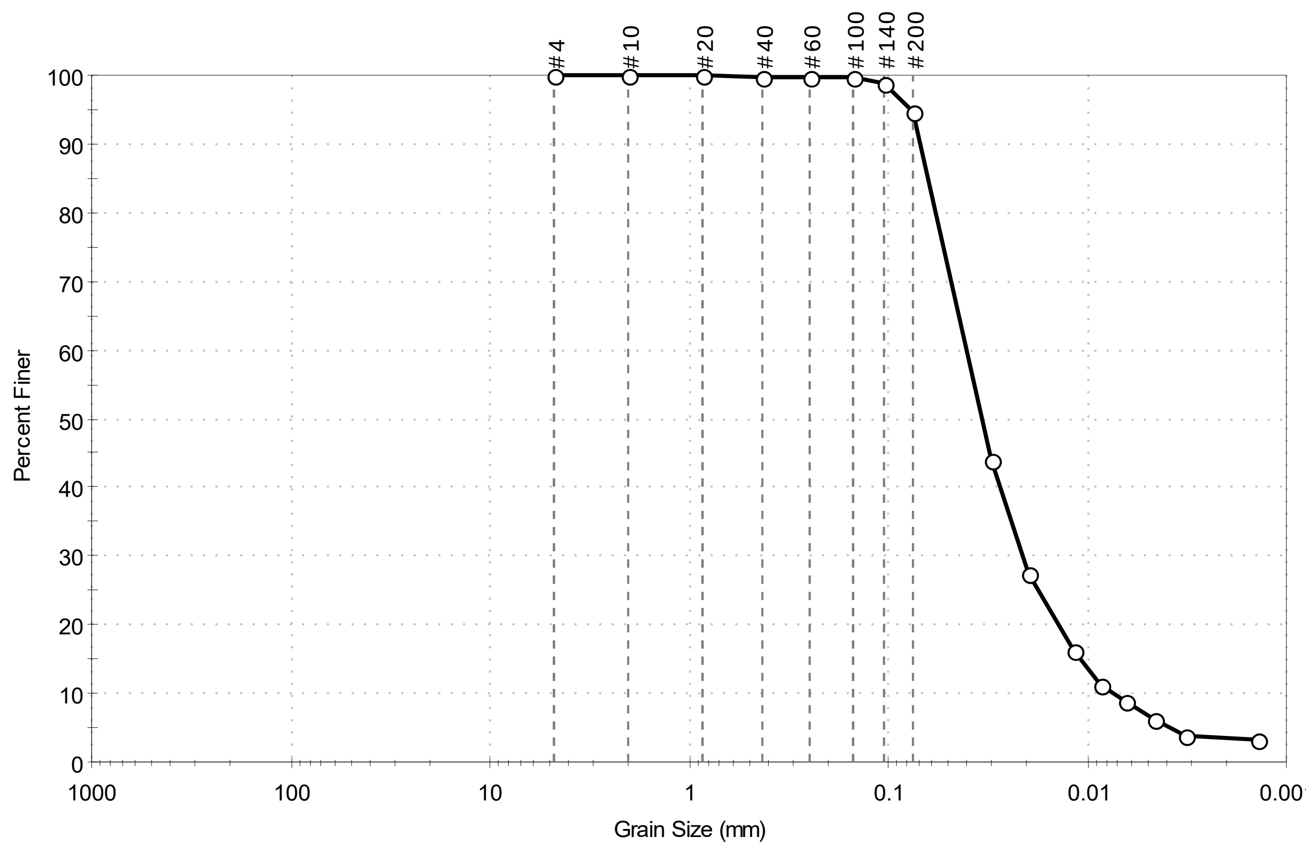
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	GEI Consultants, Inc.				
Project:	MassDOT Berkshire Line Bridge 79.90				
Location:	Lenox, MA			Project No:	GTX-310237
Boring ID:	B403	Sample Type:	jar	Tested By:	ckg
Sample ID:	S3	Test Date:	07/11/19	Checked By:	bfs
Depth :	10-12	Test Id:	513032		
Test Comment:	---				
Visual Description:	Moist, olive silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	5.4	94.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	99		
#200	0.075	95		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0300	44		
---	0.0198	28		
---	0.0118	16		
---	0.0085	11		
---	0.0064	9		
---	0.0046	6		
---	0.0032	4		
---	0.0014	3		

Coefficients

D_{85} = 0.0631 mm | D_{30} = 0.0211 mm
D_{60} = 0.0402 mm | D_{15} = 0.0108 mm
D_{50} = 0.0335 mm | D_{10} = 0.0073 mm
C_u = 5.507 | C_c = 1.517

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

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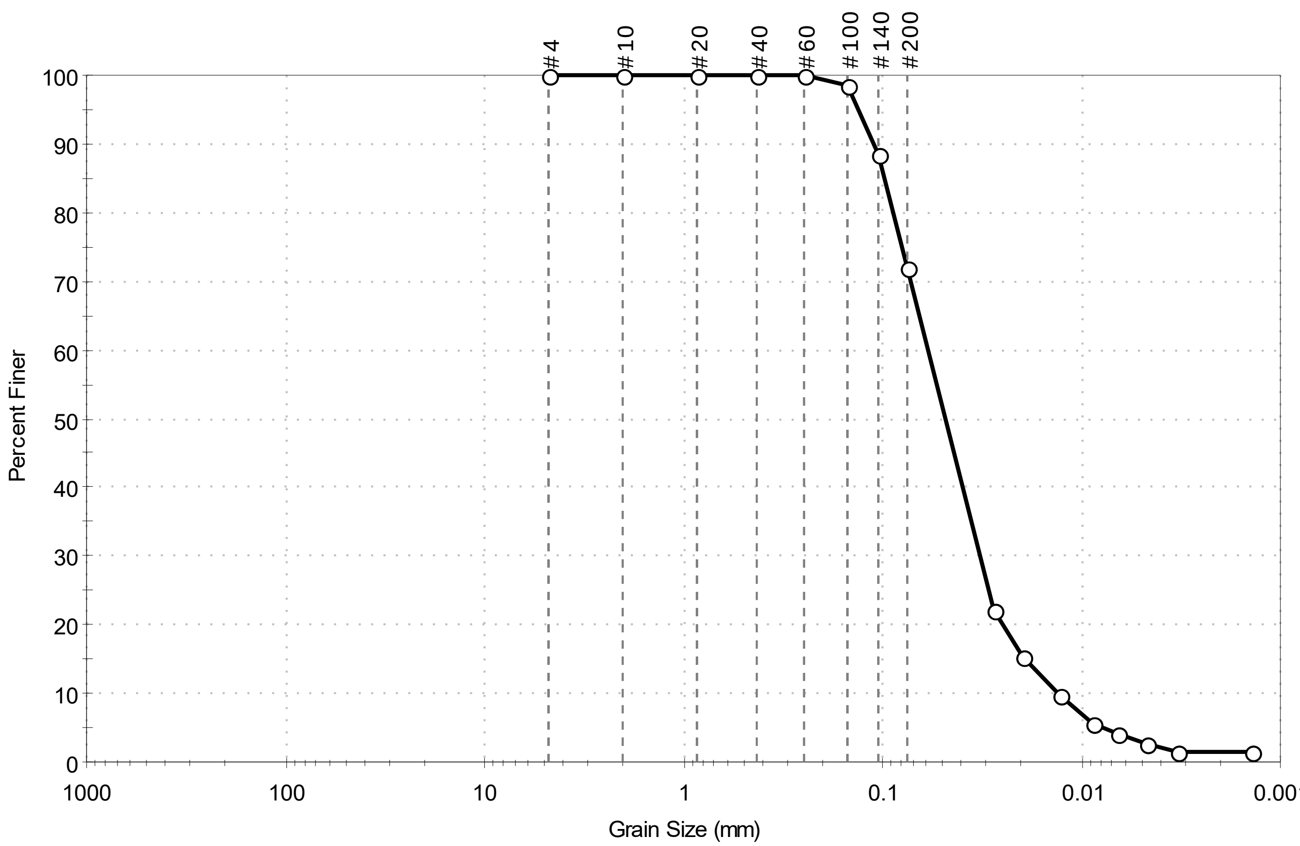
Client:	GEI Consultants, Inc.			
Project:	MassDOT Berkshire Line Bridge 79.90			
Location:	Lenox, MA		Project No:	GTX-310237
Boring ID:	B403	Sample Type: jar	Tested By:	ckg
Sample ID:	S5	Test Date: 07/11/19	Checked By:	bfs
Depth :	14-16	Test Id: 513033		

Test Comment: ---
Visual Description: Moist, olive silt with sand
Sample Comment: ---

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	27.9	72.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	99		
#140	0.11	88		
#200	0.075	72		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0274	22		
---	0.0197	15		
---	0.0128	10		
---	0.0087	6		
---	0.0066	4		
---	0.0047	3		
---	0.0033	1		
---	0.0014	1		

Coefficients

D_{85} = 0.0987 mm D_{30} = 0.0321 mm
D_{60} = 0.0588 mm D_{15} = 0.0193 mm
D_{50} = 0.0481 mm D_{10} = 0.0131 mm
C_u = 4.489 C_c = 1.338

Classification

ASTM N/A

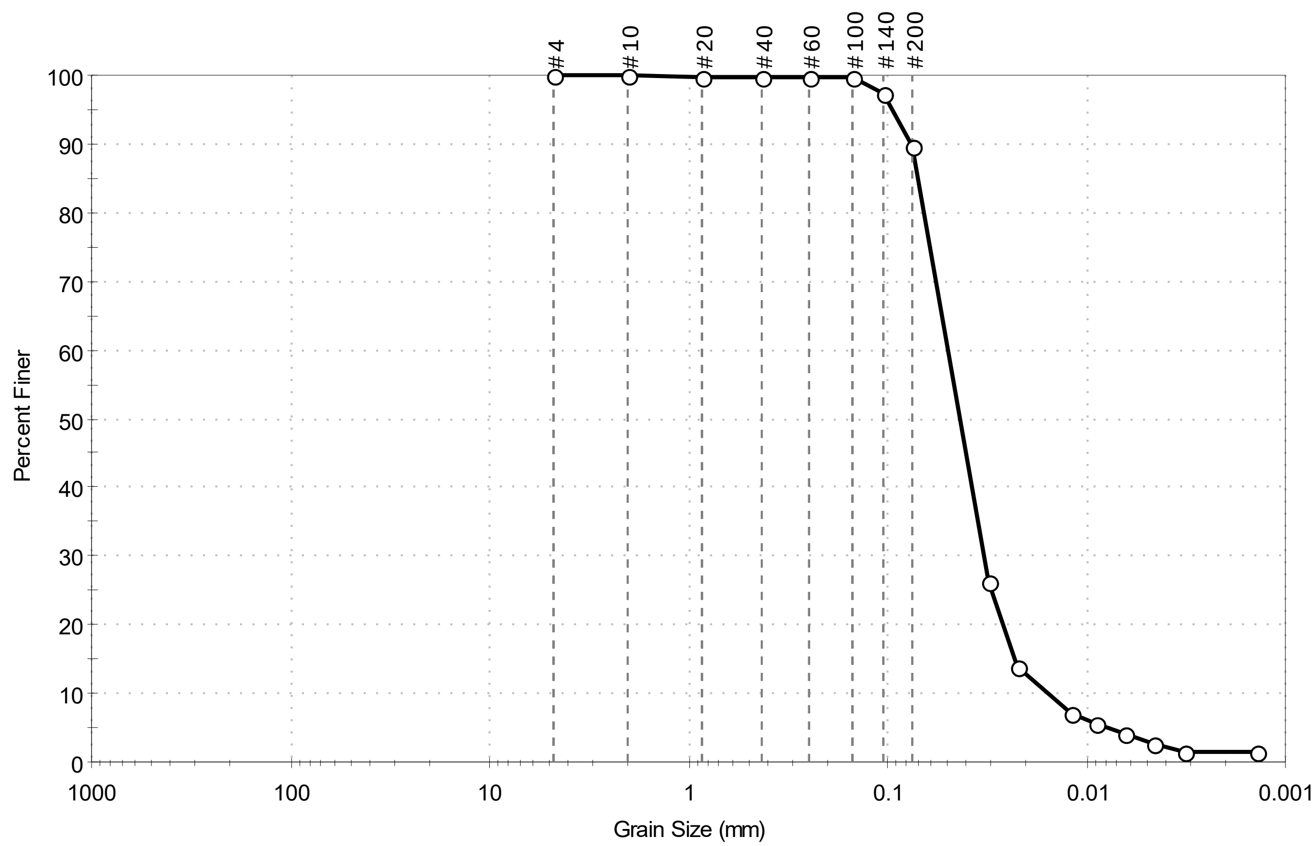
AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

Client:	GEI Consultants, Inc.				
Project:	MassDOT Berkshire Line Bridge 79.90				
Location:	Lenox, MA			Project No:	GTX-310237
Boring ID:	B403	Sample Type:	jar	Tested By:	ckg
Sample ID:	S6	Test Date:	07/11/19	Checked By:	bfs
Depth :	20-22	Test Id:	513034		
Test Comment:	---				
Visual Description:	Moist, olive silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	0.0	10.3	89.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	100		
#100	0.15	100		
#140	0.11	97		
#200	0.075	90		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0309	26		
---	0.0223	14		
---	0.0119	7		
---	0.0090	6		
---	0.0065	4		
---	0.0046	3		
---	0.0033	1		
---	0.0014	1		

Coefficients

D_{85} = 0.0703 mm	D_{30} = 0.0325 mm
D_{60} = 0.0495 mm	D_{15} = 0.0229 mm
D_{50} = 0.0430 mm	D_{10} = 0.0157 mm
C_u = 3.153	C_c = 1.359

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Appendix C

H-Pile and Micropile Lateral Analysis

GEI Consultants	Client	HDR Engineering, Inc.				
	Project	MassDOT Berkshire Line Bridge 79.90				
	By	W. Lukas	Chk.	J. Giampa	App.	J. Christensen
	Date	03/13/2020	Date	03/27/2020	Date	03 / 31/2020
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90 – Pile Analyses					

OBJECTIVE

This calculation presents the moment, shear, and mobilized soil reaction from lateral loading at the top of the pile for driven steel HP14 sections and drilled 16-inch-outer-diameter micropiles at the abutments and pier of Berkshire Line Railroad Bridge 79.90, Pond Overflow Bridge, in Lenox, Massachusetts.

ANALYTICAL METHODOLOGY

We estimated pile response at the bridge abutments and pier for a steel HP14 section and a 16-inch-outer-diameter micropile as described below:

1. Developed a soil profile that is representative of the conditions at the abutments at Bridge 79.90.
2. Estimated unit weights and strength properties of the soils based on site-specific explorations.
3. Computed the applied lateral load acting perpendicular to the pile cap at the bridge abutment, based on the unfactored longitudinal loads and revised bridge layout provided by HDR Engineering, Inc. on February 7, 2020.
4. Computed the additional passive lateral resistance of the abutment when the abutment is displaced 1 inch towards the embankment fill.
5. Prepared two LPILE models to represent a typical abutment pile and midspan pier pile.
6. Evaluated both LPILE models as HP14x117 sections and 16-inch-outer-diameter drilled micropiles.
7. Evaluated the midspan pier for both the non-scoured and scoured conditions.
8. Obtained lateral pile-head deflection, bending moment, shear force, and mobilized soil reaction versus depth for each LPILE model.
9. Compared the pile deflection computed from LPILE to the maximum deflection criteria presented in AREMA (2016.)

ELEVATION DATUM

Elevations used in this document are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88).

ASSUMPTIONS

The following assumptions were made for this analysis:

- Groundwater and river elevation, El. 953.9 (100-yr flood).
- Pinned-head loading condition at the bridge abutment and midspan pier.
- The load perpendicular to the pile cap is applied to the strong axis of the pile section.
- Passive earth pressure can be developed behind each bridge abutment.
- Piles are installed to a depth of 50 ft.
- Steel specification for HP14: ASTM A572 Gr 50.
- Micropiles have 16-inch-outer-diameter casing.
- The bridge is rigid, i.e. all piles will have the same longitudinal displacement.

SOIL PROFILE

Soil properties used in this calculation are based on GEI borings B401, B402, and B403 performed October 2 through October 9, 2018 by Aquifer Drilling and Testing, Inc.

Figure 1 presents the general geometry and soil profile used for each LPILE model.

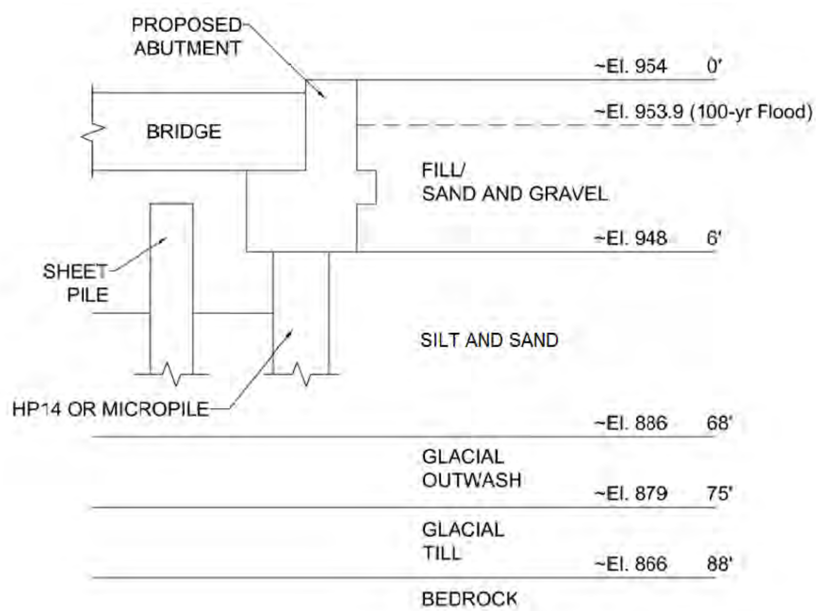


Figure 1. General Geometry and Soil Profile.

In LPILE, we modeled the pile head at elevation El. 948 for the abutment and pier piles. For the pier piles the silt and sand starts at El. 946 for the unscoured condition and El. 940.2 for the scoured condition. We assumed that the soil around the abutment piles do not experience scour because of the sheet piles in front of the piles.

LPILE SOIL PARAMETERS

Table 1 presents the soil properties used in LPILE. The LPILE soil model and soil modulus parameters were selected based on recommendations in the LPILE Technical Manual (Ensoft 2018).

Table 1. Soil Properties used in LPILE Analyses

Soil Type	LPILE Soil Model	Effective Soil Unit Weight (pcf)	Friction Angle (deg)	Soil Modulus Parameter, k (pci)
Fill / Sand & Gravel	Sand (Reese)	62.6	30	35
Silt and Sand	Sand (Reese)	57.6	32	55
Glacial Outwash	Sand (Reese)	67.6	35	86
Glacial Till	Sand (Reese)	72.6	38	120

Pcf = pounds per cubic foot; pci = pound cubic inch

The pile spacing at the abutment is equal to about 4.8 times the width (B) of the pile. We applied a P-multiplier (group reduction factor) in LPILE equal to 0.90 to account for group interaction effects based on the 2017 AASHTO LRFD Bridge Design Manual for pile spacing less than or equal to 5B.

STEEL H-PILES

Based on the soil profile shown in Figure 1 above, we expect the steel HP14 piles will be driven to the design depth in the silt and sand. We recommend using an HP14x117, which is the heaviest HP14 available. While a lighter HP14 may be able to resist the combined axial and flexural loads, the HP14x117 will provide additional stiffness and will improve lateral performance.

DRILLED MICROPILES

Based on the soil profile shown in Figure 1 above, we expect 16-inch-outer-diameter micropiles will be drilled to the design depth in the silt and sand. We recommend using 16-inch-outer-diameter, Gr 50 casing with a wall thickness of 0.500", filled with grout with a compressive strength of 5,000 psi, and with a single #18 ASTM A572 Gr 50 rebar the whole length of the pile.

DESIGN LOADS

We received the pile loads from HDR Engineering, Inc. in an email on February 7, 2020.

Unfactored - Vertical Load

Load	Abutment	Pier
Dead (kips) (Sub-Structure)	29.34	20.25
Dead (kips) (Super Structure)	53.35	106.71
Live (kips)	186.66	242.66
Impact (kips)	98.99	128.69
Total	**368.35**	**498.31**

Unfactored - Longitudinal Load

Load (Kips)	Abutment	Pier
Braking/Traction Force (LF)	106.07	106.07
Bearing Resistance Force (F)	5.34	-
Earth Pressure (E)	17.67	-
Live Load Surcharge (LF)	21.01	-
Total	**150.08**	**106.07**

(Loads provided 02/07/20)

LPILE LOAD CASES

The total lateral loading in the direction of the bridge, i.e. longitudinal loading, was provided as 150.08 kips. The pile cap beam will allow near-uniform load sharing between the three proposed piles at the abutments and piers, resulting in an equal load of 50.03 kips per pile at the abutment if all the longitudinal load is carried at one abutment.

GEI Consultants	**Client**	HDR Engineering, Inc.				
	Project	MassDOT Berkshire Line Bridge 79.90				
	By	W. Lukas	**Chk.**	J. Giampa	**App.**	J. Christensen
	Date	03/13/2020	**Date**	03/27/2020	**Date**	03 / 31/2020
Project No.	1703257	**Document No.**	N/A			
Subject	Bridge 79.90 – Pile Analyses					

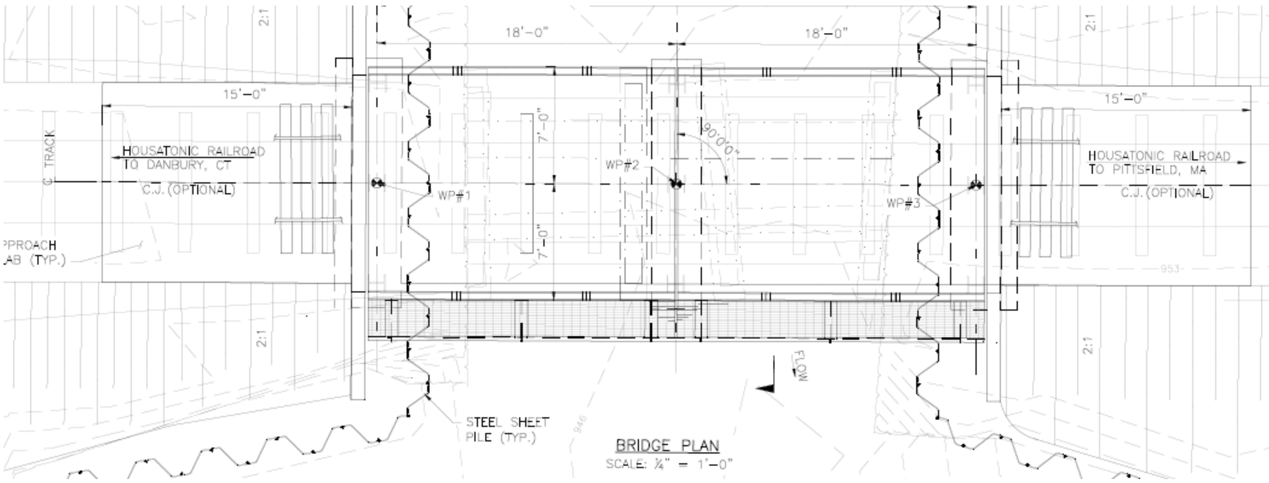


Figure 2. Proposed Bridge Layout Provided by HDR Engineering, Inc.

We modeled the pile head as a pinned connection. We have assumed that passive earth pressures can be developed behind the bridge abutment and provide additional resistance to the applied lateral load perpendicular to the pile cap.

We computed the passive soil pressure we expect to develop on the back of the abutment using research performed by MassDOT and UMass Amherst for integral abutments provided in the MassDOT LRFD Bridge Manual Section 3.10.8.

$$K = 0.43 + 5.7[1 - e^{-190(\delta_T/H)}]$$

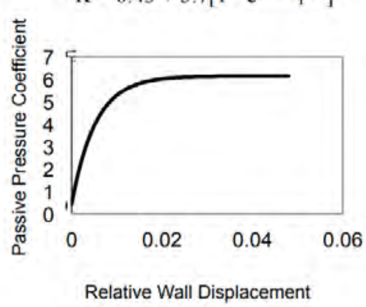


Figure 3.10.8-1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

Assuming a deformation of 1-inch at the bridge bearing elevation and an abutment height of 4.0 feet, we estimated a passive earth pressure coefficient, K_p, of 6 will be developed. Based on Fig. 2

prepared by HDR, we understand the abutment will be about 15 feet wide. The resulting passive lateral pressure behind the abutment will be:

P_p = 0.5*(4.0ft^2)*125pcf*6*15ft = 90 kips

Therefore, the applied net longitudinal load to one pile was calculated.

- Applied Lateral Load (per pile) = 50.03 kips – (90 kips / 3) = 20.03 kips

The computed maximum resultant deflections for the abutment pile, presented above, were computed to equal 0.58-inch for the HP14 section and 0.88-inch for the micropile.

Since the deflections for the HP14 section and micropile were less than 1.0-inch, the results underestimate the total lateral load resisted by the piles. Therefore, to better model the pile behavior, we iterated the abutment pile load to estimate a net lateral load such that the assumed deflection at the bridge bearing elevation, used to compute the passive soil pressure, would equal the resultant deflection output from LPILE.

Using the procedure presented above and through iteration, assuming deformation of approximately 0.64-inch at the bridge bearing elevation and an abutment height of 4.0 feet, we estimated a K_p of 5.7 will be developed by the HP14 section. The resulting passive lateral pressure behind the abutment will be:

P_p = 0.5*(4.0ft^2)*125pcf*5.7*15ft = 85.5 kips

Therefore, the applied net lateral load to the pile cap beam with the HP14 sections was calculated as

- Applied Lateral Load (per pile) = 50.03 kips– (85.5 kips / 3 piles) = 21.53 kips

Using the procedure presented above and through iteration, assuming deformation of approximately 0.89-inch at the bridge bearing elevation and an abutment height of 4.0 feet, we estimated a K_p of 5.96 will be developed by the micropile. The resulting passive lateral pressure behind the abutment will be:

P_p = 0.5*(4.0ft^2)*125pcf*5.96*15ft = 89.4 kips

Therefore, the applied net lateral load to the pile cap beam with the micropile was calculated as

- Applied Lateral Load (per pile) = 50.03 kips– (89.4 kips / 3 piles) = 20.23 kips

To capture p-delta effects in the LPILE models, we applied an axial load equal to 122.8 kips per pile for the abutment piles and 166.1 kips per pile for the pier piles. The displacements calculated at the abutment piles were used as an applied condition to the pier piles to calculate the moment and lateral loading.

Table 2. Load Cases

Pile Location	Pile Type	Axial Load (kips)	Lateral Load at Pile Head (kips)	Applied Displacement at Pile Head (in)
Abutment	HP14-117	122.8	21.53	N/A
	Micropile	122.8	20.23	N/A
Pier	HP14-117	166.1	N/A	0.64
	Micropile	166.1	N/A	0.89

RESULTS

The results of these analyses are based on the assumed steel HP14x117 pile section or 16.0-inch-outer-diameter micropile with #18 rebar, a pile length of 50 feet, and a rigid bridge deck resulting in equal longitudinal displacement for abutment and pier piles. LPILE computed lateral pile deflection, bending moment, shear force, and mobilized soil reaction versus depth for each soil profile (Appendix A). The results are summarized in Table 3 below. The minimum recommended pile length shown in Table 3 is based on the depth below which the mobilized soil reaction is negligible rounded up to the nearest multiple of 5 feet.

The computed resultant lateral deflections are less than 1-inch, which satisfies the deformation criteria specified in AREMA Section 2.2.3.j.3. Based on our evaluation, 3-pile bents (at both bridge abutments and midspan pier) will resist the applied longitudinal loads.

Table 3. LPILE Results

Pile Location	Pile Type	Scoured? (Yes/No)	Deflection at Top of Pile (in)	Max Moment (kip-ft)	Max Shear (kips)	Recom. Minimum Pile Length (ft)
Abutment	HP14-117	No	0.72	130.5	21.5[1]	45
	Micropile	No	0.74	117.5	20.2[1]	45
Pier	HP14-117	No	0.72[1]	113.8	14.9	45
	HP14-117	Yes	0.72[1]	76.3	8.4	50
	Micropile	No	0.74[1]	105.0	14.2	45
	Micropile	Yes	0.74[1]	73.4	8.2	50

Note 1: Max. Shear or Deflection at Top of Pile is an Input.

REFERENCES

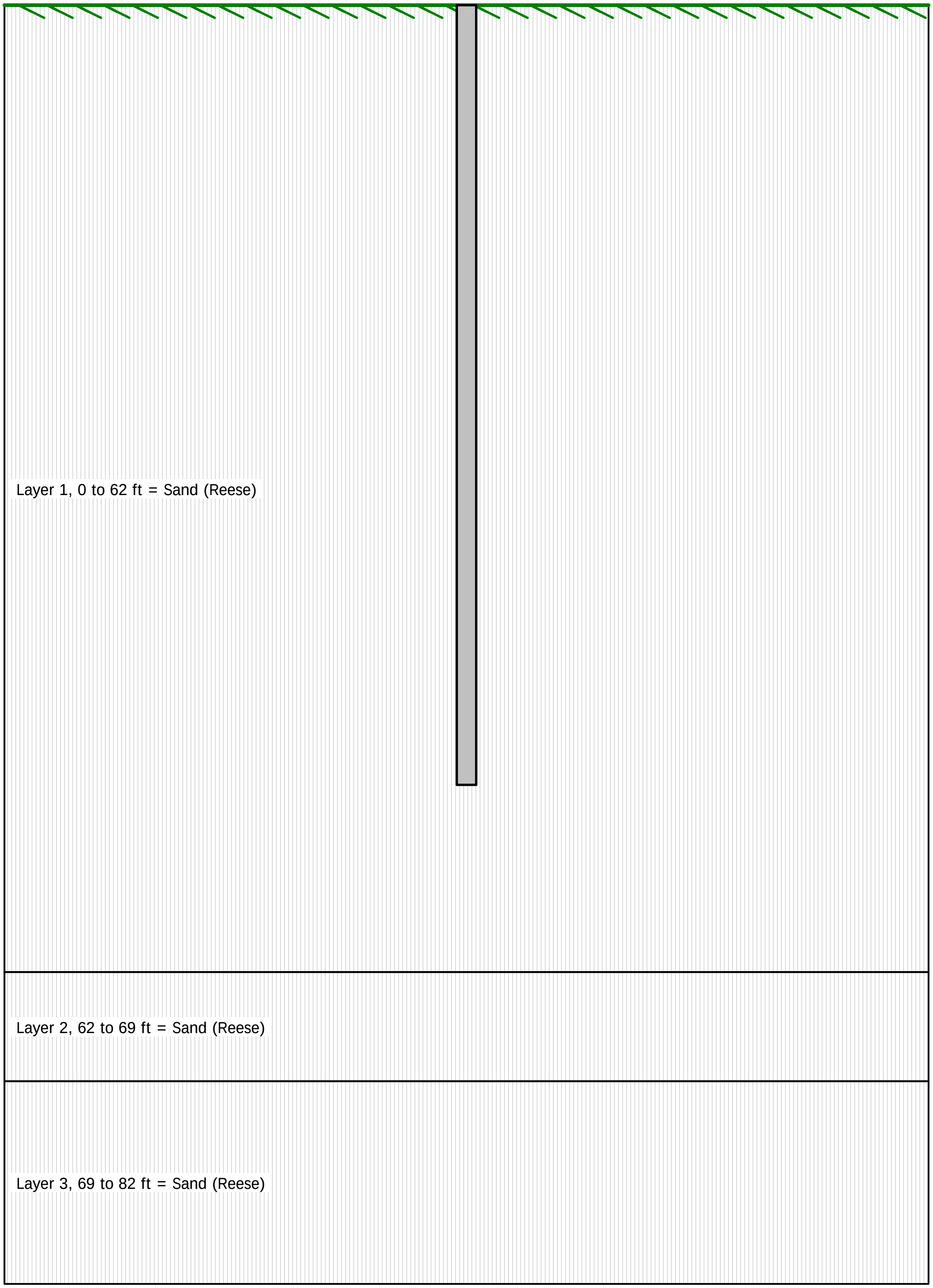
1. AREMA (2016). AREMA Railway Manual, 2018 Edition, Manual for Railway Engineering.
2. Ensoft, Inc. (2018). Technical Manual for LPILE 2018: A program to Analyze Deep Foundations Under Lateral Loading.
3. Highway Division Massachusetts Department of Transportation (2013). MassDOT LRFD Bridge Manual – Part I Design Guidelines, 2013 Edition.
4. AASHTO (2017). AASHOT LRFD Bridge Design Specifications, 8th Edition.

GEI Consultants	Client	HDR Engineering, Inc.				
	Project	MassDOT Berkshire Line Bridge 79.90				
	By	W. Lukas	Chk.	J. Giampa	App.	J. Christensen
	Date	03/13/2020	Date	03/27/2020	Date	03 / 31/2020
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90 – Pile Analyses					

ATTACHMENT: LPILE OUTPUT

Abutment HP Pile

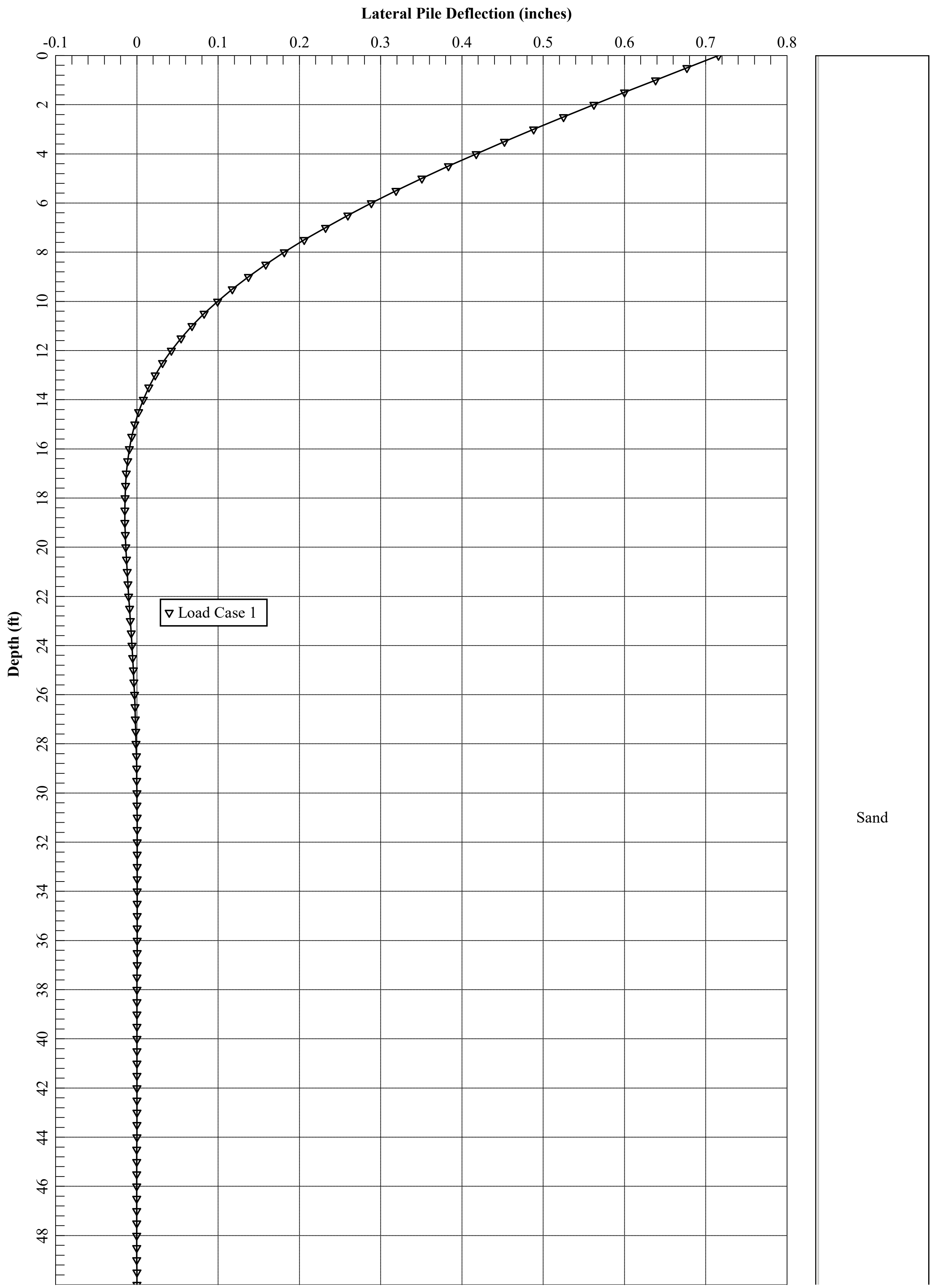
Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips



LPile 2018.10.09, © 2018 by Ensoft, Inc.

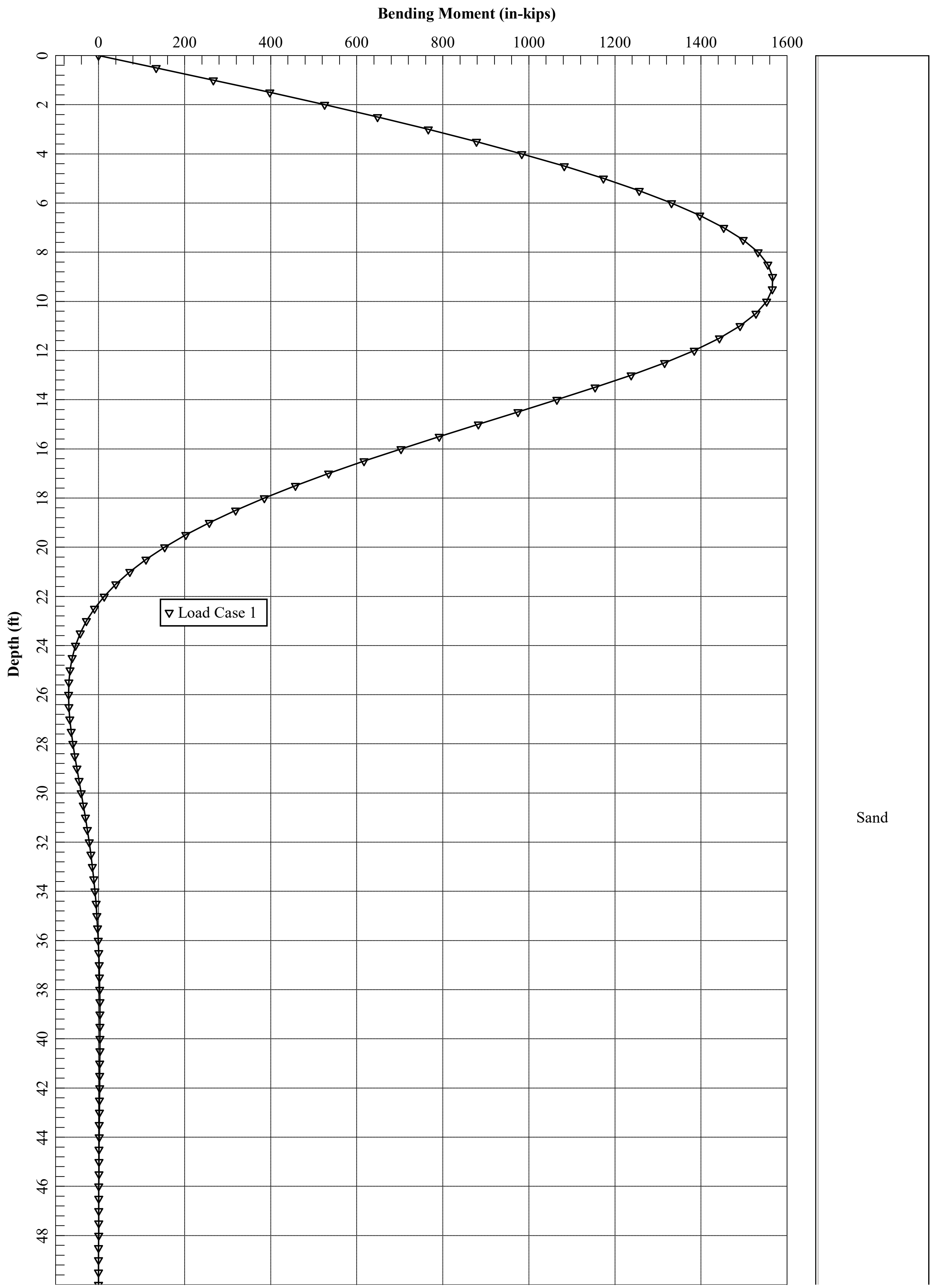
Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips



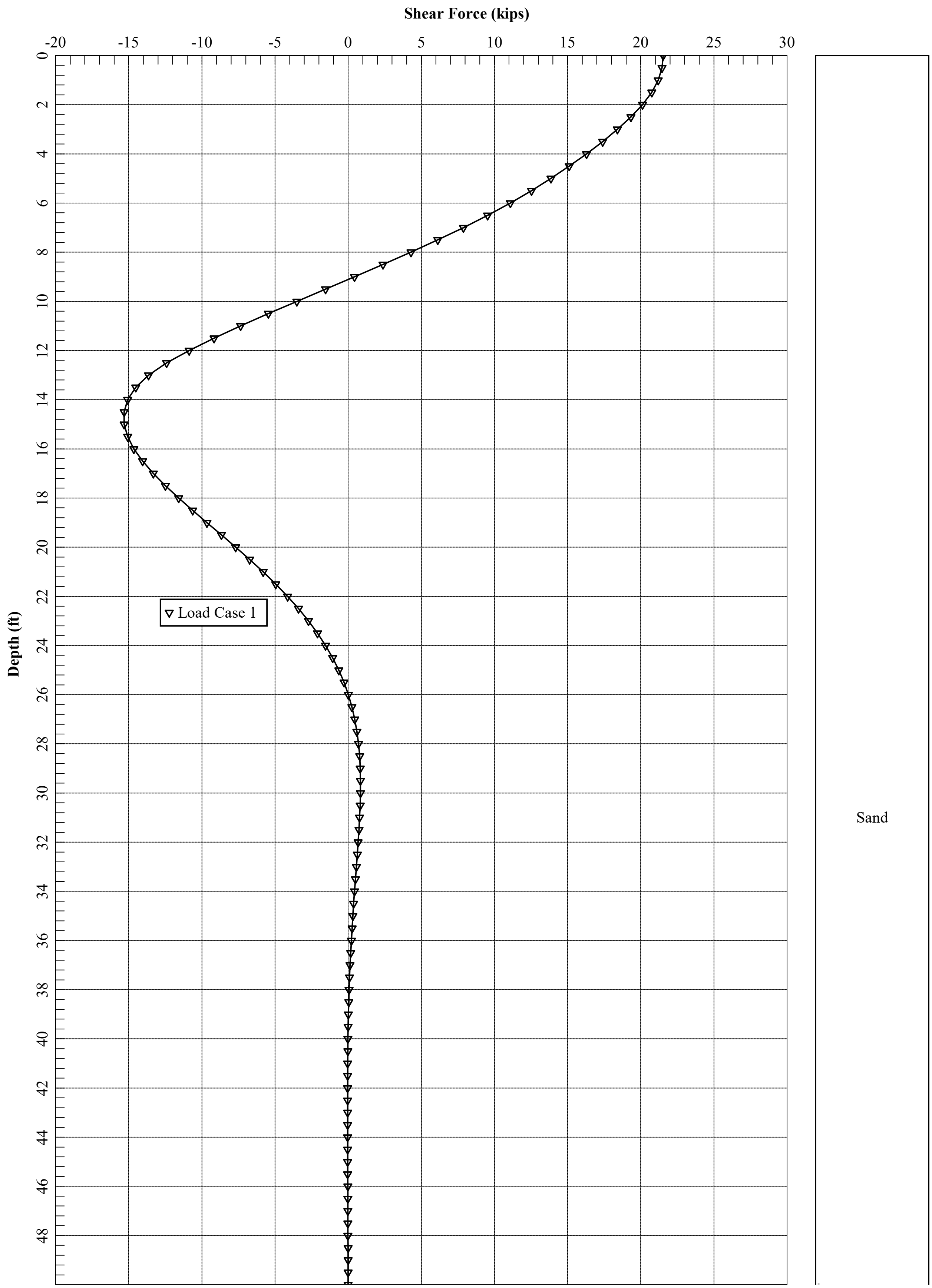
Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips



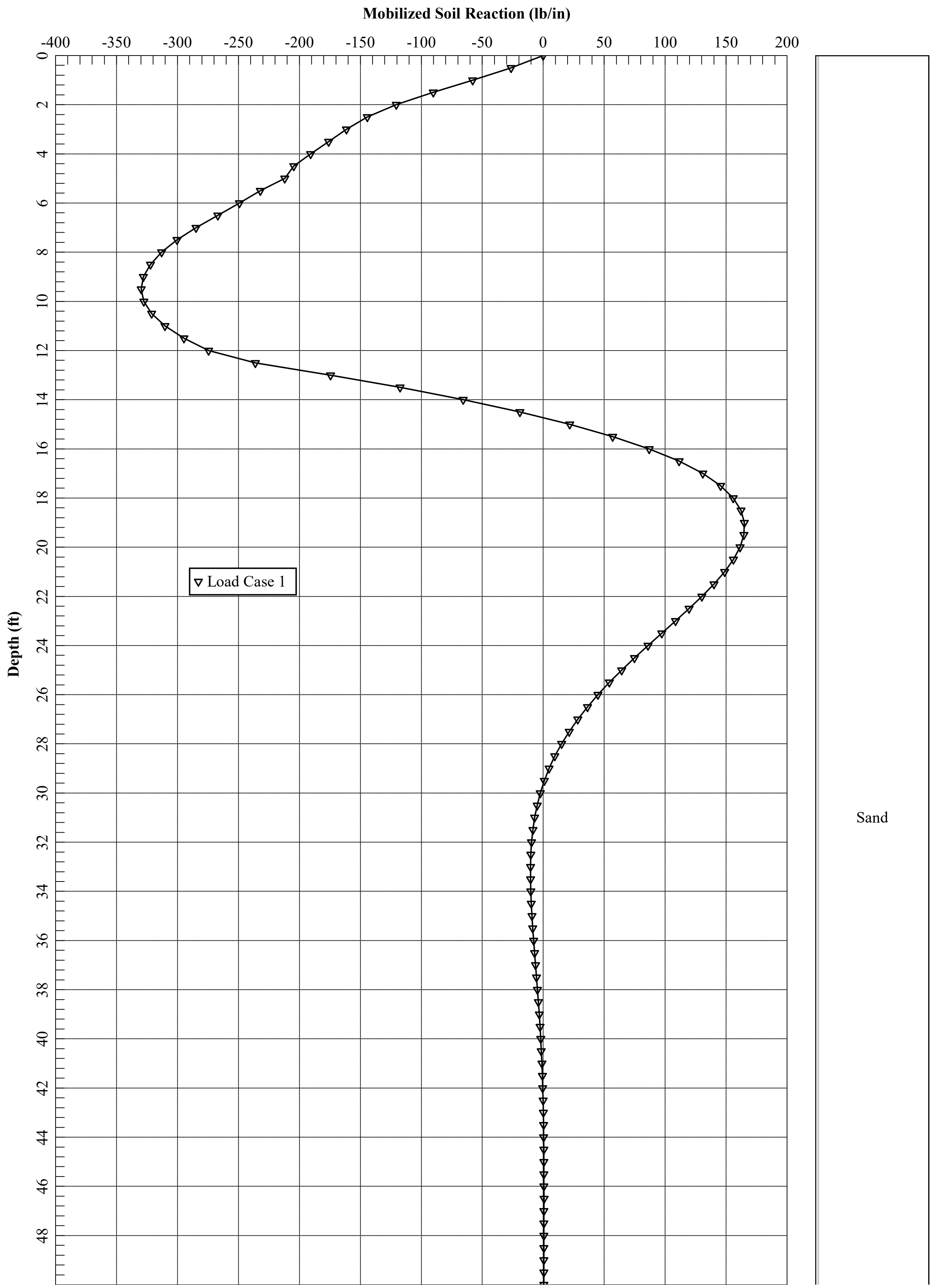
Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips



Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips



Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

```
================================================================================

                  LPile for Windows(Beta), Version 2018-10.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
                           © 1985-2018 by Ensoft, Inc.
                               All Rights Reserved

================================================================================

This copy of LPile is being used by:

Serial Number of Security Device: 239146454

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--------------------------------------------------------------------------------
                                     Files Used for Analysis
       --------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name                 of                 input                 data                 file:
1. Abutment HP Pile.lp10

Name of output report file:
1. Abutment HP Pile.lp10

Name of plot output file:
1. Abutment HP Pile.lp10

Name of runtime message file:
1. Abutment HP Pile.lp10



--------------------------------------------------------------------------------
```

Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

```
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  March 27, 2020              Time:   9:48:39



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
```

```
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats




--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                          =            1
Total length of pile                                     =       50.000 ft
Depth of ground surface below top of pile                =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.9000
  2           50.000           14.9000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                     =    50.000000 ft
   Pile width                                            =    14.900000 in
   Shear capacity of section                             =       0.0000 lbs
```

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians

Pile Batter Angle                                      =        0.000 degrees
                                                       =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =       0.0000 ft
   Distance from top of pile to bottom of layer        =    62.000000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =    55.000000 pci
   Subgrade k at bottom of layer                       =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    62.000000 ft
   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
```

Distance from top of pile to bottom of layer	=	82.000000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Friction angle at top of layer	=	38.000000 deg.
Friction angle at bottom of layer	=	38.000000 deg.
Subgrade k at top of layer	=	120.000000 pci
Subgrade k at bottom of layer	=	120.000000 pci

(Depth of the lowest soil layer extends 32.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand	0.00	57.6000	32.0000	55.0000
	(Reese, et al.)	62.0000	57.6000	32.0000	55.0000
2	Sand	62.0000	67.6000	35.0000	86.0000
	(Reese, et al.)	69.0000	67.6000	35.0000	86.0000
3	Sand	69.0000	72.6000	38.0000	120.0000
	(Reese, et al.)	82.0000	72.6000	38.0000	120.0000

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

```
Static loading criteria were used when computing p-y curves for all analyses.



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load        Condition                Condition             Axial Thrust      Compute Top y
 No.    Type            1                        2                  Force, lbs      vs. Pile Length
-----   ----    --------------------   -----------------------   ----------------   ---------------
   1     1     V =       21530. lbs   M =       0.0000 in-lbs            122800.          No

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Strong Axis:
---------------------------------------------

Length of Section                                      =    50.000000 ft
Flange Width                                           =    14.900000 in
Section Depth                                          =    14.200000 in
Flange Thickness                                       =     0.805000 in
Web Thickness                                          =     0.805000 in
Yield Stress of Pipe                                   =    50.000000 ksi
```

Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

```
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    34.123950 sq. in.
Moment of Inertia                                      =        1211. in^4
Elastic Bending Stiffness                              =    35125694. kip-in^2
Plastic Modulus, Z                                     =   192.566083in^3
Plastic Moment Capacity = Fy Z                         =        9628.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =     1706.197 kips
Nominal Axial Tensile Capacity                         =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
     1              122.800

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =    122.800 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000471	165.3129203	35100995.	33.4483667	4.5586625	
0.00000942	330.6258406	35100995.	20.2741833	5.5186795	
0.00001413	495.9387609	35100995.	15.8827889	6.4786965	
0.00001884	661.2516812	35100995.	13.6870917	7.4387135	
0.00002355	826.5646015	35100995.	12.3696733	8.3987305	
0.00002826	991.8775218	35100995.	11.4913944	9.3587475	
0.00003297	1157.	35100995.	10.8640524	10.3187645	
0.00003768	1323.	35100995.	10.3935458	11.2787815	
0.00004239	1488.	35100995.	10.0275963	12.2387985	
0.00004710	1653.	35100995.	9.7348367	13.1988155	
0.00005181	1818.	35100995.	9.4953061	14.1588325	
0.00005652	1984.	35100995.	9.2956972	15.1188495	
0.00006123	2149.	35100995.	9.1267974	16.0788665	

0.00006593	2314.	35100995.	8.9820262	17.0388834	
0.00007064	2480.	35100995.	8.8565578	17.9989004	
0.00007535	2645.	35100995.	8.7467729	18.9589174	
0.00008006	2810.	35100995.	8.6499039	19.9189344	
0.00008477	2976.	35100995.	8.5637981	20.8789514	
0.00008948	3141.	35100995.	8.4867561	21.8389684	
0.00009419	3306.	35100995.	8.4174183	22.7989854	
0.00009890	3472.	35100995.	8.3546841	23.7590024	
0.0001036	3637.	35100995.	8.2976530	24.7190194	
0.0001083	3802.	35100995.	8.2455812	25.6790364	
0.0001130	3968.	35100995.	8.1978486	26.6390534	
0.0001177	4133.	35100995.	8.1539347	27.5990704	
0.0001225	4298.	35100995.	8.1133987	28.5590874	
0.0001272	4463.	35100995.	8.0758654	29.5191044	
0.0001319	4629.	35100995.	8.0410131	30.4791214	
0.0001366	4794.	35100995.	8.0085644	31.4391384	
0.0001413	4959.	35100995.	7.9782789	32.3991554	
0.0001460	5125.	35100995.	7.9499473	33.3591724	
0.0001507	5290.	35100995.	7.9233865	34.3191894	
0.0001554	5455.	35100995.	7.8984354	35.2792063	
0.0001601	5621.	35100995.	7.8749520	36.2392233	
0.0001648	5786.	35100995.	7.8528105	37.1992403	
0.0001695	5951.	35100995.	7.8318991	38.1592573	
0.0001743	6117.	35100995.	7.8121180	39.1192743	
0.0001790	6282.	35100995.	7.7933781	40.0792913	
0.0001837	6447.	35100995.	7.7755991	41.0393083	
0.0001931	6778.	35100995.	7.7426431	42.9593423	
0.0002025	7108.	35100995.	7.7127527	44.8793763	
0.0002119	7439.	35100995.	7.6855193	46.7994103	
0.0002214	7770.	35100995.	7.6606035	48.7194443	
0.0002308	8090.	35057060.	7.6440380	50.0000000	Y
0.0002402	8346.	34747396.	7.6681543	50.0000000	Y
0.0002496	8502.	34059545.	7.7514821	50.0000000	Y
0.0002590	8601.	33204822.	7.8625604	50.0000000	Y
0.0002684	8693.	32382094.	7.9704194	50.0000000	Y
0.0002779	8778.	31592251.	8.0748470	50.0000000	Y
0.0002873	8858.	30833841.	8.1759971	50.0000000	Y
0.0002967	8930.	30096993.	8.2690149	50.0000000	Y
0.0003061	8995.	29382024.	8.3542446	50.0000000	Y
0.0003155	9050.	28680798.	8.4260855	50.0000000	Y
0.0003250	9100.	28001782.	8.4897587	50.0000000	Y
0.0003344	9143.	27343905.	8.5459864	50.0000000	Y
0.0003438	9178.	26696647.	8.5856027	50.0000000	Y
0.0003532	9207.	26065148.	8.6126409	50.0000000	Y
0.0003626	9228.	25446955.	8.6254469	50.0000000	Y
0.0003721	9243.	24843517.	8.6256079	50.0000000	Y
0.0003815	9257.	24266970.	8.6256620	50.0000000	Y

0.0003909	9270.	23715553.	8.6253937	50.0000000	Y
0.0004003	9283.	23187895.	8.6252741	50.0000000	Y
0.0004097	9294.	22682426.	8.6256213	50.0000000	Y
0.0004192	9304.	22197875.	8.6255072	50.0000000	Y
0.0004286	9314.	21733073.	8.6252609	50.0000000	Y
0.0004380	9324.	21286830.	8.6257432	50.0000000	Y
0.0004474	9332.	20858003.	8.6252795	50.0000000	Y
0.0004568	9340.	20445704.	8.6255675	50.0000000	Y
0.0004663	9348.	20049057.	8.6254079	50.0000000	Y
0.0004757	9355.	19667155.	8.6255004	50.0000000	Y
0.0004851	9362.	19299256.	8.6254221	50.0000000	Y
0.0004945	9368.	18944575.	8.6255406	50.0000000	Y
0.0005039	9374.	18602478.	8.6253224	50.0000000	Y
0.0005134	9380.	18272284.	8.6256889	50.0000000	Y
0.0005228	9386.	17953447.	8.6251069	50.0000000	Y
0.0005322	9391.	17645279.	8.6257599	50.0000000	Y
0.0005416	9395.	17347318.	8.6253404	50.0000000	Y
0.0005510	9400.	17059150.	8.6254079	50.0000000	Y
0.0005604	9404.	16780281.	8.6257296	50.0000000	Y
0.0005981	9420.	15749173.	8.6251293	50.0000000	Y
0.0006358	9433.	14836027.	8.6252795	50.0000000	Y
0.0006735	9443.	14021961.	8.6254079	50.0000000	Y
0.0007112	9453.	13291836.	8.6253082	50.0000000	Y
0.0007488	9460.	12633440.	8.6249764	50.0000000	Y
0.0007865	9467.	12036648.	8.6253271	50.0000000	Y
0.0008242	9473.	11493442.	8.6260170	50.0000000	Y
0.0008619	9478.	10996785.	8.6252365	50.0000000	Y
0.0008995	9482.	10541068.	8.6254602	50.0000000	Y
0.0009372	9486.	10121457.	8.6255918	50.0000000	Y
0.0009749	9489.	9733814.	8.6253404	50.0000000	Y
0.0010126	9493.	9374657.	8.6254930	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	122.8000000000	9493.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	2777841.
2	62.0000	62.0000	No	No	2777841.	0.00
3	69.0000	69.0000	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 21530.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 122800.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*h	Distrib. Lat. Load

Abutment HP Pile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 21.53 kips

feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	0.7156	2.71E-06	21530.	-0.00645	3599.	3.51E+10	0.00	0.00	0.00
0.5000	0.6769	133929.	21451.	-0.00643	4422.	3.51E+10	-26.4207	234.1970	0.00
1.0000	0.6383	266890.	21198.	-0.00640	5240.	3.51E+10	-57.8499	543.7449	0.00
1.5000	0.6001	397734.	20754.	-0.00634	6045.	3.51E+10	-90.1432	901.2977	0.00
2.0000	0.5622	525283.	20122.	-0.00626	6830.	3.51E+10	-120.6271	1287.	0.00
2.5000	0.5249	648424.	19327.	-0.00616	7587.	3.51E+10	-144.2592	1649.	0.00
3.0000	0.4883	766290.	18410.	-0.00604	8312.	3.51E+10	-161.4012	1983.	0.00
3.5000	0.4524	878248.	17398.	-0.00590	9001.	3.51E+10	-175.9275	2333.	0.00
4.0000	0.4175	983763.	16298.	-0.00574	9650.	3.51E+10	-190.7099	2741.	0.00
4.5000	0.3835	1082288.	15112.	-0.00557	10256.	3.51E+10	-204.5229	3200.	0.00
5.0000	0.3507	1173314.	13863.	-0.00537	10815.	3.51E+10	-211.9381	3626.	0.00
5.5000	0.3190	1256563.	12531.	-0.00517	11327.	3.51E+10	-231.9508	4362.	0.00
6.0000	0.2887	1331303.	11088.	-0.00494	11787.	3.51E+10	-249.1942	5180.	0.00
6.5000	0.2597	1396904.	9540.	-0.00471	12191.	3.51E+10	-266.7905	6164.	0.00
7.0000	0.2321	1452725.	7885.	-0.00447	12534.	3.51E+10	-284.8633	7363.	0.00
7.5000	0.2061	1498108.	6129.	-0.00422	12813.	3.51E+10	-300.3896	8746.	0.00
8.0000	0.1815	1532488.	4289.	-0.00396	13025.	3.51E+10	-312.9487	10343.	0.00
8.5000	0.1586	1555409.	2384.	-0.00369	13166.	3.51E+10	-322.2176	12191.	0.00
9.0000	0.1372	1566534.	433.3502	-0.00343	13234.	3.51E+10	-327.9082	14337.	0.00
9.5000	0.1175	1565658.	-1540.	-0.00316	13229.	3.51E+10	-329.7668	16842.	0.00
10.0000	0.09933	1552712.	-3512.	-0.00289	13149.	3.51E+10	-327.5719	19787.	0.00
10.5000	0.08278	1527779.	-5458.	-0.00263	12996.	3.51E+10	-321.1284	23277.	0.00
11.0000	0.06779	1491092.	-7352.	-0.00237	12770.	3.51E+10	-310.2565	27460.	0.00
11.5000	0.05433	1443048.	-9167.	-0.00212	12475.	3.51E+10	-294.7730	32552.	0.00
12.0000	0.04235	1384211.	-10875.	-0.00188	12113.	3.51E+10	-274.4565	38880.	0.00
12.5000	0.03180	1315319.	-12406.	-0.00165	11689.	3.51E+10	-236.0863	44550.	0.00
13.0000	0.02259	1237762.	-13638.	-0.00143	11212.	3.51E+10	-174.4168	46332.	0.00
13.5000	0.01465	1153771.	-14513.	-0.00122	10695.	3.51E+10	-117.4570	48114.	0.00
14.0000	0.00789	1065405.	-15063.	-0.00104	10152.	3.51E+10	-65.6214	49896.	0.00
14.5000	0.00223	974543.	-15317.	-8.61E-04	9593.	3.51E+10	-19.1840	51678.	0.00
15.0000	-0.00244	882868.	-15310.	-7.02E-04	9029.	3.51E+10	21.7121	53460.	0.00
15.5000	-0.00620	791863.	-15073.	-5.59E-04	8469.	3.51E+10	57.0419	55242.	0.00
16.0000	-0.00914	702812.	-14642.	-4.31E-04	7921.	3.51E+10	86.8858	57024.	0.00
16.5000	-0.01137	616800.	-14047.	-3.18E-04	7392.	3.51E+10	111.4153	58806.	0.00
17.0000	-0.01296	534722.	-13320.	-2.20E-04	6888.	3.51E+10	130.8788	60588.	0.00
17.5000	-0.01401	457287.	-12490.	-1.35E-04	6411.	3.51E+10	145.5879	62370.	0.00
18.0000	-0.01458	385037.	-11586.	-6.30E-05	5967.	3.51E+10	155.9029	64152.	0.00
18.5000	-0.01476	318350.	-10631.	-2.93E-06	5557.	3.51E+10	162.2205	65934.	0.00
19.0000	-0.01462	257463.	-9650.	4.63E-05	5182.	3.51E+10	164.9604	67716.	0.00
19.5000	-0.01421	202483.	-8661.	8.56E-05	4844.	3.51E+10	164.5553	69498.	0.00
20.0000	-0.01359	153400.	-7683.	1.16E-04	4542.	3.51E+10	161.4397	71280.	0.00
20.5000	-0.01281	110111.	-6731.	1.39E-04	4276.	3.51E+10	156.0415	73062.	0.00
21.0000	-0.01193	72425.	-5817.	1.54E-04	4044.	3.51E+10	148.7744	74844.	0.00
21.5000	-0.01096	40086.	-4950.	1.64E-04	3845.	3.51E+10	140.0314	76626.	0.00
22.0000	-0.00996	12782.	-4139.	1.68E-04	3677.	3.51E+10	130.1797	78408.	0.00

22.5000	-0.00895	-9836.	-3390.	1.69E-04	3659.	3.51E+10	119.5570	80190.	0.00
23.0000	-0.00794	-28149.	-2706.	1.65E-04	3772.	3.51E+10	108.4685	81972.	0.00
23.5000	-0.00696	-42554.	-2089.	1.59E-04	3860.	3.51E+10	97.1854	83754.	0.00
24.0000	-0.00603	-53454.	-1540.	1.51E-04	3927.	3.51E+10	85.9440	85536.	0.00
24.5000	-0.00515	-61254.	-1057.	1.41E-04	3975.	3.51E+10	74.9459	87318.	0.00
25.0000	-0.00433	-66348.	-639.2392	1.30E-04	4007.	3.51E+10	64.3587	89100.	0.00
25.5000	-0.00359	-69117.	-283.2104	1.19E-04	4024.	3.51E+10	54.3176	90882.	0.00
26.0000	-0.00291	-69922.	14.5230	1.07E-04	4029.	3.51E+10	44.9269	92664.	0.00
26.5000	-0.00230	-69100.	258.0929	9.50E-05	4024.	3.51E+10	36.2630	94446.	0.00
27.0000	-0.00177	-66964.	452.0104	8.33E-05	4011.	3.51E+10	28.3762	96228.	0.00
27.5000	-0.00130	-63799.	601.0201	7.22E-05	3991.	3.51E+10	21.2937	98010.	0.00
28.0000	-9.03E-04	-59859.	709.9700	6.16E-05	3967.	3.51E+10	15.0229	99792.	0.00
28.5000	-5.64E-04	-55370.	783.6997	5.18E-05	3939.	3.51E+10	9.5536	101574.	0.00
29.0000	-2.82E-04	-50530.	826.9444	4.27E-05	3909.	3.51E+10	4.8613	103356.	0.00
29.5000	-5.19E-05	-45509.	844.2565	3.45E-05	3879.	3.51E+10	0.9094	105138.	0.00
30.0000	1.32E-04	-40450.	839.9424	2.71E-05	3847.	3.51E+10	-2.3475	106920.	0.00
30.5000	2.74E-04	-35470.	818.0145	2.07E-05	3817.	3.51E+10	-4.9618	108702.	0.00
31.0000	3.80E-04	-30664.	782.1568	1.50E-05	3787.	3.51E+10	-6.9907	110484.	0.00
31.5000	4.54E-04	-26106.	735.7024	1.02E-05	3759.	3.51E+10	-8.4940	112266.	0.00
32.0000	5.02E-04	-21851.	681.6227	6.06E-06	3733.	3.51E+10	-9.5325	114048.	0.00
32.5000	5.27E-04	-17936.	622.5253	2.66E-06	3709.	3.51E+10	-10.1666	115830.	0.00
33.0000	5.33E-04	-14385.	560.6602	-1.07E-07	3687.	3.51E+10	-10.4551	117612.	0.00
33.5000	5.25E-04	-11208.	497.9333	-2.29E-06	3668.	3.51E+10	-10.4539	119394.	0.00
34.0000	5.06E-04	-8406.	435.9238	-3.97E-06	3650.	3.51E+10	-10.2159	121176.	0.00
34.5000	4.78E-04	-5971.	375.9074	-5.20E-06	3635.	3.51E+10	-9.7896	122958.	0.00
35.0000	4.43E-04	-3887.	318.8809	-6.04E-06	3623.	3.51E+10	-9.2193	124740.	0.00
35.5000	4.05E-04	-2135.	265.5896	-6.56E-06	3612.	3.51E+10	-8.5445	126522.	0.00
36.0000	3.65E-04	-690.6813	216.5556	-6.80E-06	3603.	3.51E+10	-7.8002	128304.	0.00
36.5000	3.24E-04	473.3010	172.1055	-6.82E-06	3602.	3.51E+10	-7.0165	130086.	0.00
37.0000	2.83E-04	1385.	132.3987	-6.66E-06	3607.	3.51E+10	-6.2191	131868.	0.00
37.5000	2.44E-04	2072.	97.4543	-6.36E-06	3611.	3.51E+10	-5.4291	133650.	0.00
38.0000	2.07E-04	2563.	67.1757	-5.97E-06	3614.	3.51E+10	-4.6638	135432.	0.00
38.5000	1.72E-04	2887.	41.3747	-5.50E-06	3616.	3.51E+10	-3.9366	137214.	0.00
39.0000	1.41E-04	3068.	19.7927	-4.99E-06	3618.	3.51E+10	-3.2574	138996.	0.00
39.5000	1.12E-04	3132.	2.1202	-4.46E-06	3618.	3.51E+10	-2.6334	140778.	0.00
40.0000	8.71E-05	3100.	-11.9865	-3.93E-06	3618.	3.51E+10	-2.0688	142560.	0.00
40.5000	6.51E-05	2994.	-22.8905	-3.41E-06	3617.	3.51E+10	-1.5658	144342.	0.00
41.0000	4.62E-05	2830.	-30.9616	-2.91E-06	3616.	3.51E+10	-1.1245	146124.	0.00
41.5000	3.02E-05	2626.	-36.5658	-2.44E-06	3615.	3.51E+10	-0.7435	147906.	0.00
42.0000	1.68E-05	2395.	-40.0571	-2.01E-06	3613.	3.51E+10	-0.4203	149688.	0.00
42.5000	5.98E-06	2149.	-41.7711	-1.63E-06	3612.	3.51E+10	-0.1511	151470.	0.00
43.0000	-2.67E-06	1896.	-42.0194	-1.28E-06	3610.	3.51E+10	0.06828	153252.	0.00
43.5000	-9.39E-06	1646.	-41.0870	-9.78E-07	3609.	3.51E+10	0.2425	155034.	0.00
44.0000	-1.44E-05	1405.	-39.2296	-7.17E-07	3607.	3.51E+10	0.3766	156816.	0.00
44.5000	-1.80E-05	1177.	-36.6729	-4.97E-07	3606.	3.51E+10	0.4756	158598.	0.00
45.0000	-2.04E-05	965.4218	-33.6126	-3.14E-07	3605.	3.51E+10	0.5445	160380.	0.00
45.5000	-2.18E-05	773.7168	-30.2152	-1.65E-07	3603.	3.51E+10	0.5880	162162.	0.00

46.0000	-2.23E-05	603.0822	-26.6193	-4.73E-08	3602.	3.51E+10	0.6107	163944.	0.00
46.5000	-2.23E-05	454.3554	-22.9375	4.31E-08	3601.	3.51E+10	0.6166	165726.	0.00
47.0000	-2.18E-05	327.7683	-19.2593	1.10E-07	3601.	3.51E+10	0.6095	167508.	0.00
47.5000	-2.10E-05	223.0814	-15.6530	1.57E-07	3600.	3.51E+10	0.5926	169290.	0.00
48.0000	-1.99E-05	139.7006	-12.1690	1.88E-07	3600.	3.51E+10	0.5687	171072.	0.00
48.5000	-1.87E-05	76.7761	-8.8426	2.07E-07	3599.	3.51E+10	0.5401	172854.	0.00
49.0000	-1.75E-05	33.2847	-5.6971	2.16E-07	3599.	3.51E+10	0.5084	174636.	0.00
49.5000	-1.62E-05	8.0926	-2.7468	2.19E-07	3599.	3.51E+10	0.4750	176418.	0.00
50.0000	-1.48E-05	0.00	0.00	2.20E-07	3599.	3.51E+10	0.4406	89100.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection            =     0.71555366 inches
Computed slope at pile head     =    -0.00644515 radians
Maximum bending moment          =       1566534. inch-lbs
Maximum shear force             =         21530. lbs
Depth of maximum bending moment =     9.00000000 feet below pile head
Depth of maximum shear force    =       0.000000 feet below pile head
Number of iterations            =             12
Number of zero deflection points =             3
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs

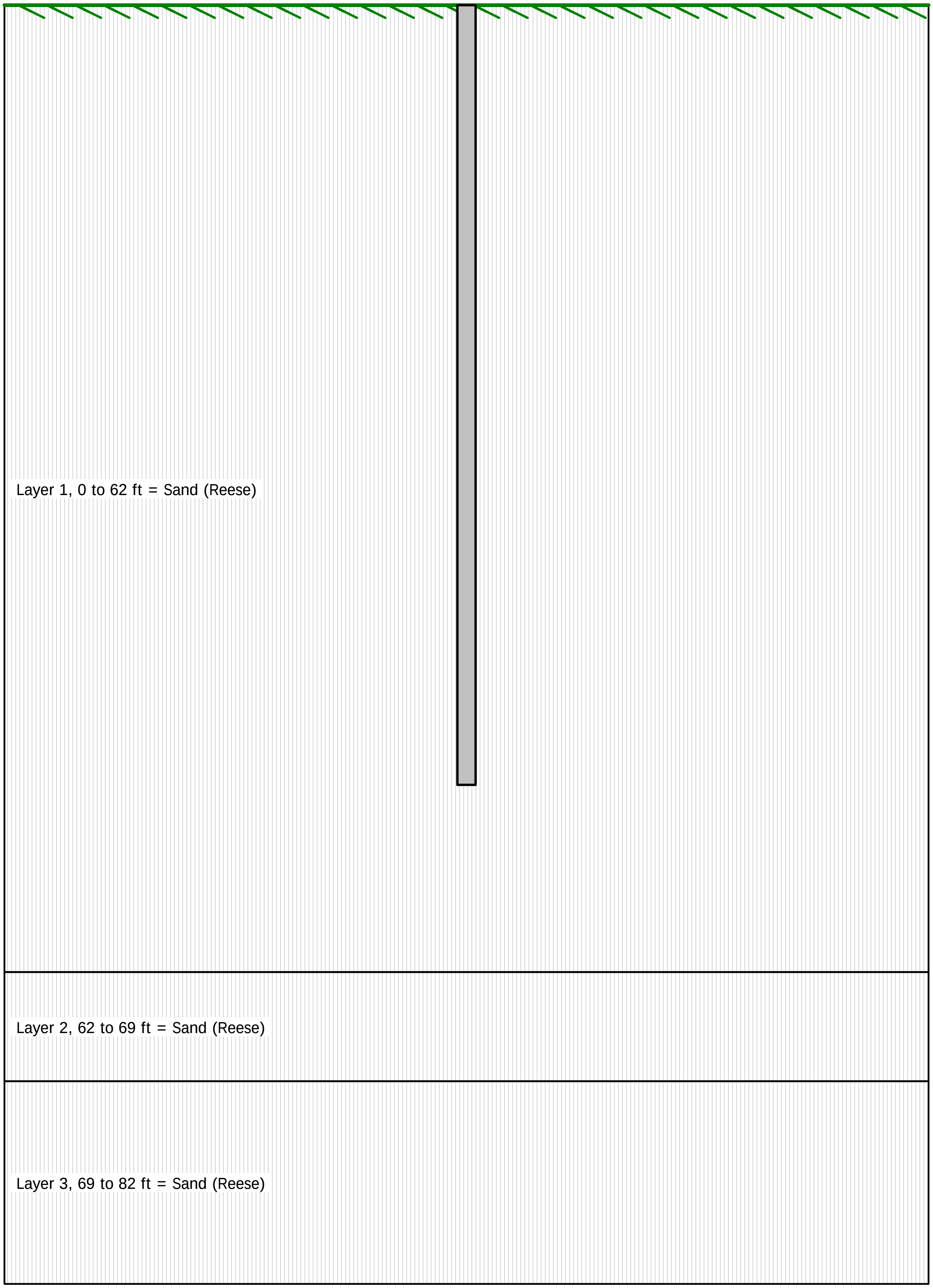
```
  1  V, lb     21530.  M, in-lb        0.00    122800.     0.7156   -0.00645     21530.   1566534.


Maximum pile-head deflection = 0.7155536569 inches
Maximum pile-head rotation   = -0.0064451465 radians = -0.369280 deg.

The analysis ended normally.
```

Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips



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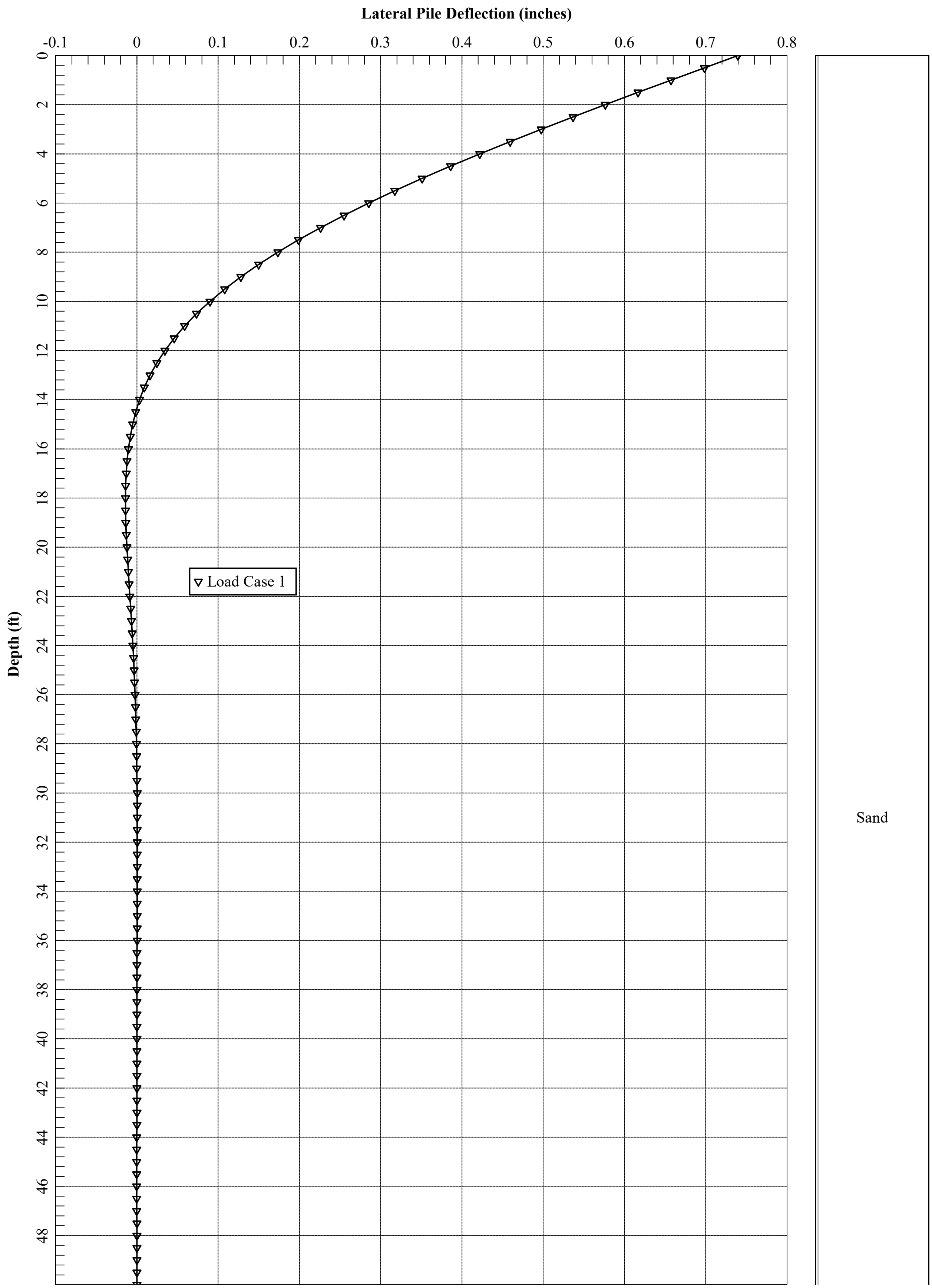
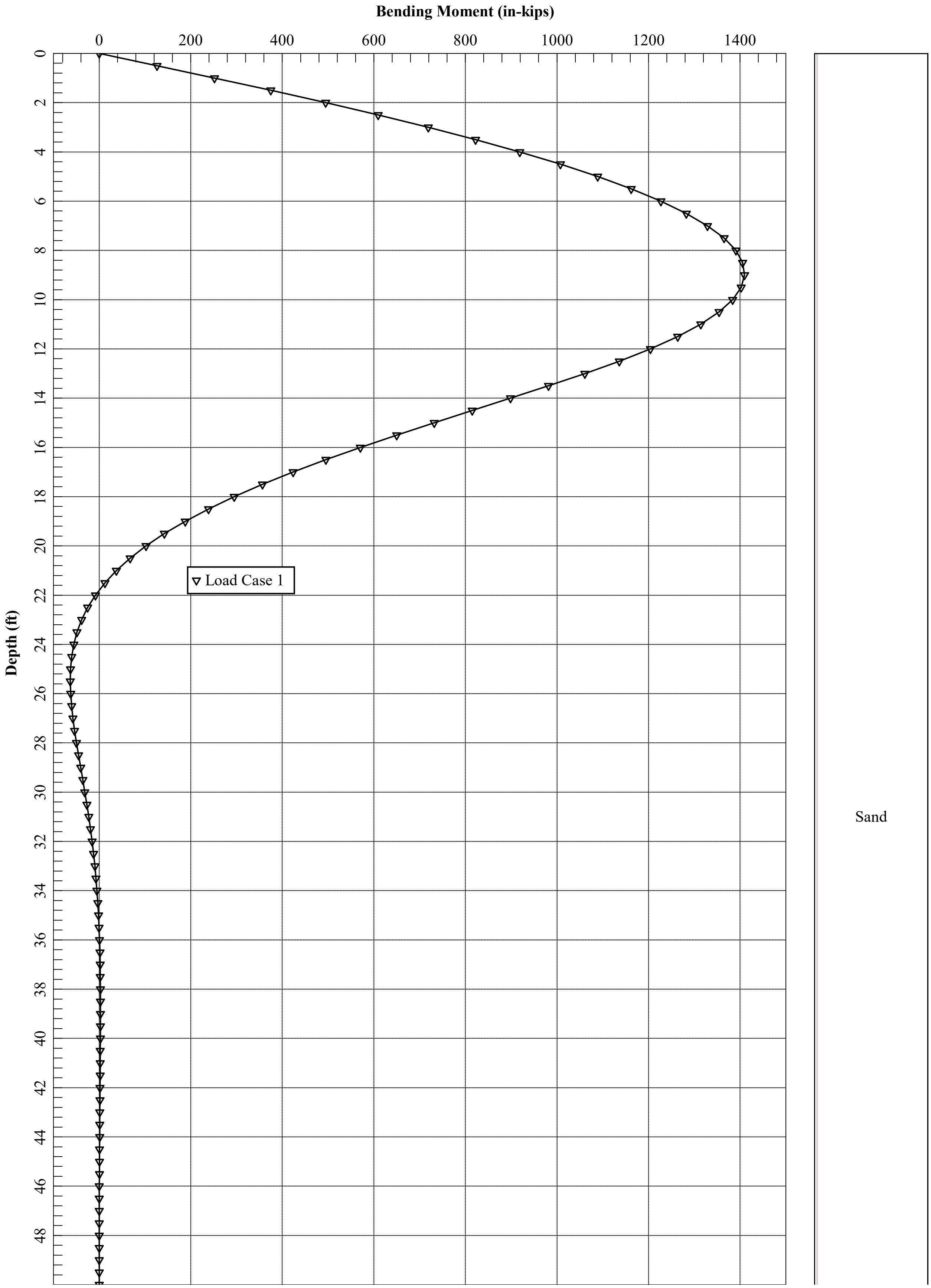
Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips



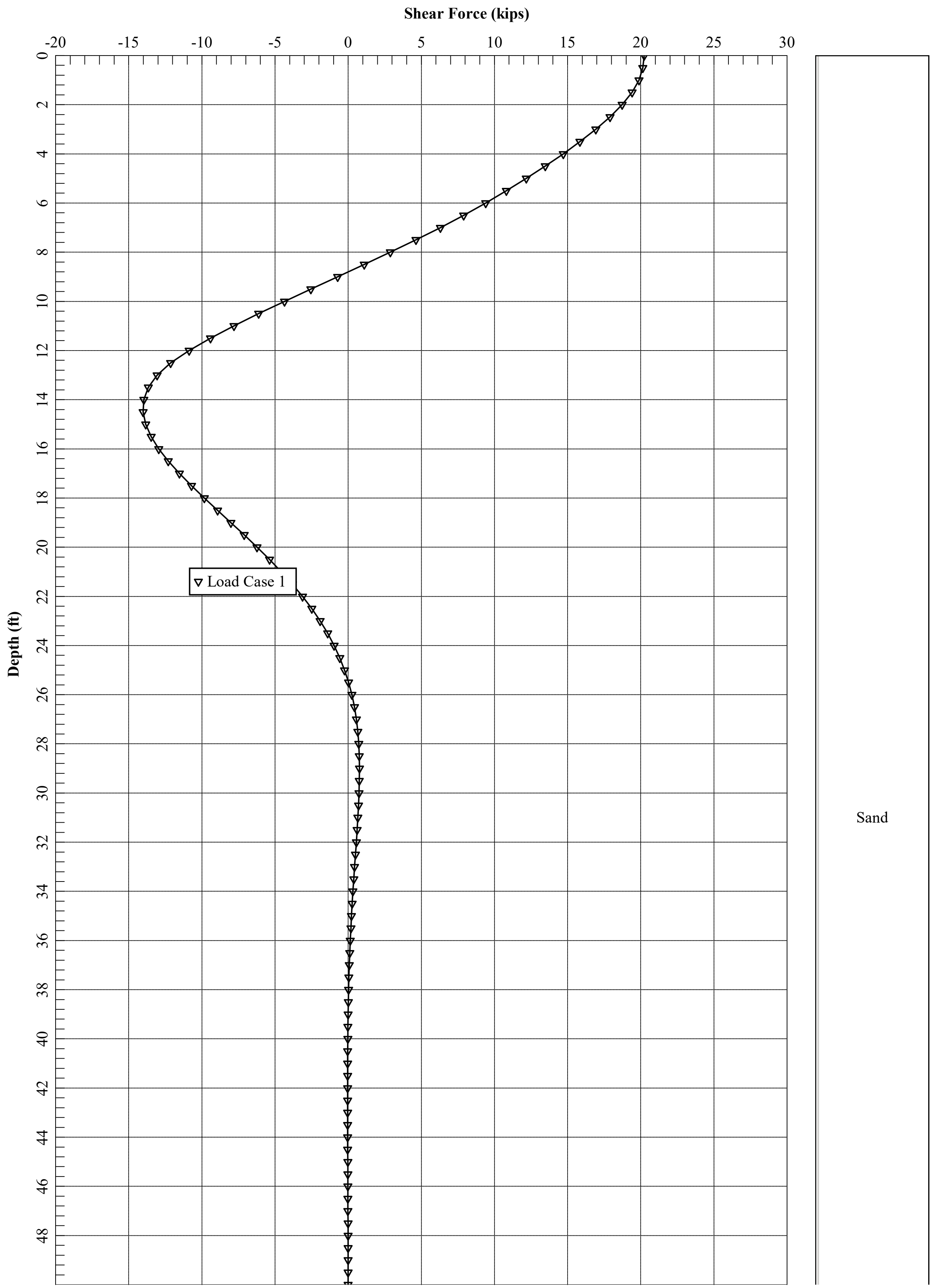
Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips



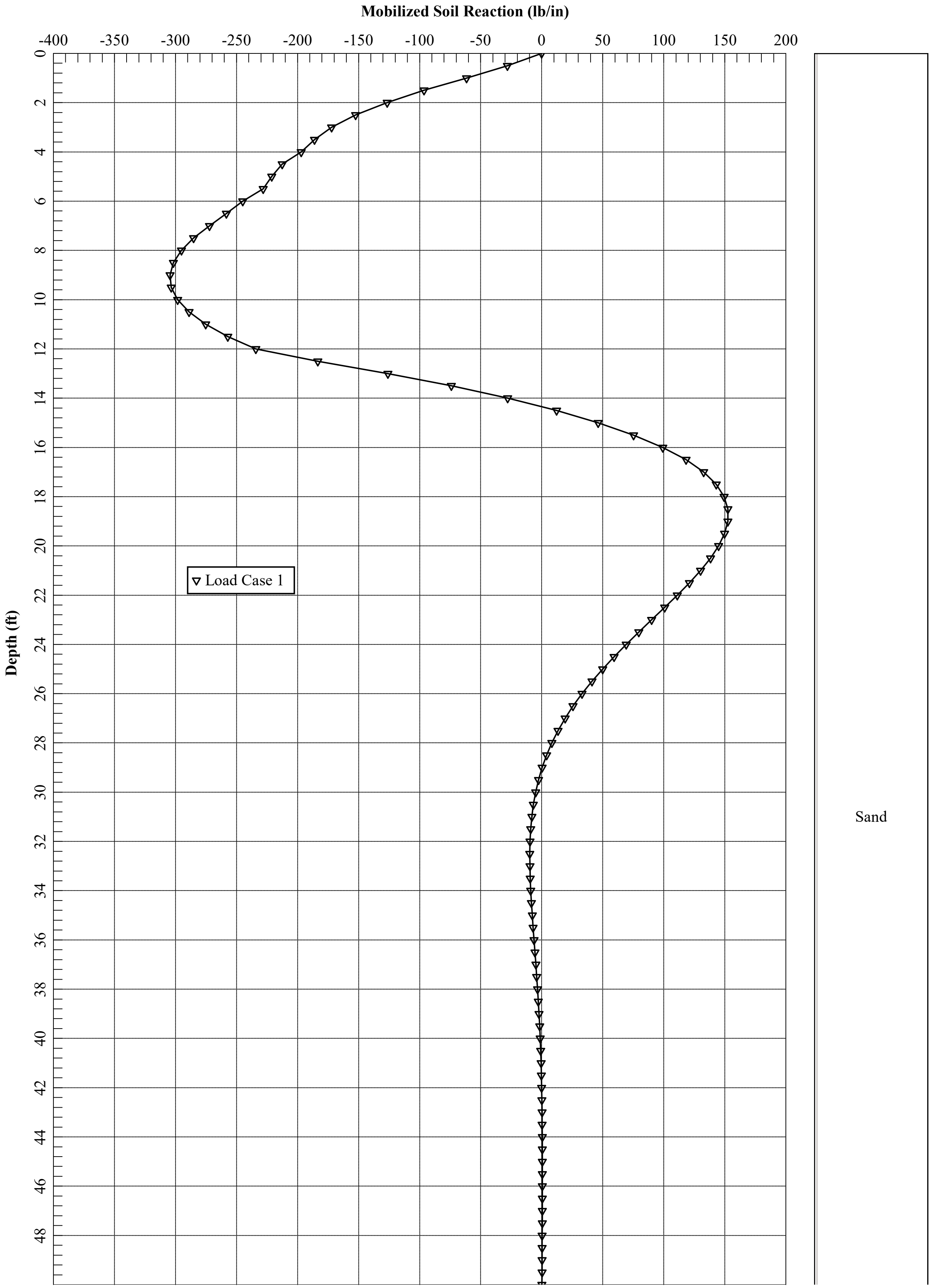
Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips



Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips



Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips

```
===============================================================================

                 LPile for Windows(Beta), Version 2018-10.009

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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-------------------------------------------------------------------------------
                                     Files Used for Analysis
       -------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name of input data file:
1. Abutment Micropile.lp10

Name of output report file:
1. Abutment Micropile.lp10

Name of plot output file:
1. Abutment Micropile.lp10

Name of runtime message file:
1. Abutment Micropile.lp10
```

```
--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  March 27, 2020              Time:  10:01:31



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified
```

```
 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =             1
Total length of pile                                   =        50.000 ft
Depth of ground surface below top of pile              =        0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           16.0000
  2           50.000           16.0000


Input Structural Properties for Pile Sections:
```

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----------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                =    50.000000 ft
   Casing outside diameter                          =    16.000000 in
   Shear capacity of section                        =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =       0.0000 ft
   Distance from top of pile to bottom of layer     =    62.000000 ft
   Effective unit weight at top of layer            =    57.600000 pcf
   Effective unit weight at bottom of layer         =    57.600000 pcf
   Friction angle at top of layer                   =    32.000000 deg.
   Friction angle at bottom of layer                =    32.000000 deg.
   Subgrade k at top of layer                       =    55.000000 pci
   Subgrade k at bottom of layer                    =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =    62.000000 ft
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   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
   Distance from top of pile to bottom of layer        =    82.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =   120.000000 pci
   Subgrade k at bottom of layer                       =   120.000000 pci


 (Depth of the lowest soil layer extends 32.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
Layer           Name             Depth      Unit Wt.     Friction        kpy
 Num.     (p-y Curve Type)        ft           pcf          deg.          pci
-----   -------------------   ----------   ----------   ----------   ----------
  1            Sand                 0.00      57.6000      32.0000      55.0000
          (Reese, et al.)        62.0000      57.6000      32.0000      55.0000
  2            Sand              62.0000      67.6000      35.0000      86.0000
          (Reese, et al.)        69.0000      67.6000      35.0000      86.0000
  3            Sand              69.0000      72.6000      38.0000     120.0000
          (Reese, et al.)        82.0000      72.6000      38.0000     120.0000


--------------------------------------------------------------------------------
                    p-y Modification Factors for Group Action
--------------------------------------------------------------------------------
```

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 20230. lbs	M = 0.0000 in-lbs	122800.	No

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                    =    50.000000 ft
Outer Diameter of Casing                             =    16.000000 in
Concrete Cover Thickness Inside Casing               =     2.000000 in
Casing Wall Thickness                                =     0.500000 in
Moment of Inertia of Steel Casing                    =   731.942001 in^4
Yield Stress of Casing                               =       50000. psi
Elastic Modulus of Casing                            =    29000000. psi
Number of Reinforcing Bars                           =            1 bar
Area of Single Reinforcing Bar                       =     4.000000 sq. in.
Edge-to-Edge Bar Spacing                             =    -2.257000 in
Maximum Concrete Aggregate Size                      =     0.750000 in
Ratio of Bar Spacing to Aggregate Size               =        -3.01
Offset of Center of Rebar Cage from Center of Pile   =       0.0000 in
Yield Stress of Reinforcing Bars                     =       50000. psi
Modulus of Elasticity of Reinforcing Bars            =    29000000. psi
Gross Area of Pile                                   =   201.061930 sq. in.
Area of Concrete                                     =   172.714587 sq. in.
Cross-sectional Area of Steel Casing                 =    24.347343 sq. in.
Area of All Steel (Casing and Bars)                  =    28.347343 sq. in.
Area Ratio of All Steel to Gross Area of Pile        =        14.10 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =     2151.404 kips
Tensile Load for Cracking of Concrete                =     -174.557 kips
Nominal Axial Tensile Capacity                       =    -1417.367 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X              Y
```

Number	inches	sq. in.	inches	inches
1	2.257000	4.000000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.330086 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	122.800

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Abutment Micropile

Axial Load: 122.8 kips
Lateral Load at Pile Head: 20.23 kips

Axial Thrust Force = 122.800 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	40.7770574	32621646.	68.4060269	0.00008551	0.00006551	0.3967827	2.4768185	2.4768185	
0.00000250	81.5531147	32621246.	38.2062587	0.00009552	0.00005552	0.4417517	2.7641538	2.7641538	
0.00000375	122.3289453	32621052.	28.1411133	0.0001055	0.00004553	0.4865244	3.0516461	3.0516461	
0.00000500	163.1044359	32620887.	23.1096236	0.0001155	0.00003555	0.5311003	3.3392954	3.3392954	
0.00000625	203.8794730	32620716.	20.0915962	0.0001256	0.00002557	0.5754792	3.6271018	3.6271018	
0.00000750	244.6539432	32620526.	18.0802999	0.0001356	0.00001560	0.6196607	3.9150653	3.9150653	
0.00000875	285.4277330	32620312.	16.6442787	0.0001456	0.00000564	0.6636443	4.2031857	4.2031857	
0.00001000	326.2007295	32620073.	15.5678042	0.0001557	-0.00000432	0.7074298	4.4914630	4.4914630	
0.00001125	366.9718450	32619720.	14.7310203	0.0001657	-0.00001428	0.7510165	4.7798954	4.7798954	
0.00001250	407.7336782	32618694.	14.0619672	0.0001758	-0.00002423	0.7944011	5.0684632	5.0684632	
0.00001375	448.4769727	32616507.	13.5148353	0.0001858	-0.00003417	0.8375794	5.3571406	5.3571406	
0.00001500	489.1947034	32612980.	13.0590945	0.0001959	-0.00004411	0.8805480	5.6459061	5.6459061	
0.00001625	529.8818980	32608117.	12.6736188	0.0002059	-0.00005405	0.9233042	5.9347429	5.9347429	
0.00001750	570.5350319	32602002.	12.3433259	0.0002160	-0.00006399	0.9658459	6.2236379	6.2236379	
0.00001875	611.1516037	32594752.	12.0571610	0.0002261	-0.00007393	1.0081715	6.5125814	6.5125814	
0.00002000	651.7297944	32586490.	11.8068368	0.0002361	-0.00008386	1.0502798	6.8015654	6.8015654	
0.00002125	692.2682882	32577331.	11.5860186	0.0002462	-0.00009380	1.0921699	7.0905840	7.0905840	
0.00002250	732.7660790	32567381.	11.3897814	0.0002563	-0.0001037	1.1338409	7.3796324	7.3796324	
0.00002375	773.2224180	32556733.	11.2142383	0.0002663	-0.0001137	1.1752922	7.6687067	7.6687067	
0.00002500	773.2224180	30928897.	10.7868734	0.0002697	-0.0001303	1.1886911	7.7624833	7.7624833	C
0.00002625	787.5473519	30001804.	10.6206176	0.0002788	-0.0001412	1.2259393	8.0240452	8.0240452	C
0.00002750	820.3334023	29830306.	10.4684445	0.0002879	-0.0001521	1.2628882	8.2847846	8.2847846	C
0.00002875	852.9787329	29668825.	10.3285803	0.0002969	-0.0001631	1.2995471	8.5447539	8.5447539	C
0.00003000	885.4912968	29516377.	10.1994968	0.0003060	-0.0001740	1.3359188	8.8039623	8.8039623	C
0.00003125	917.9031617	29372901.	10.0801113	0.0003150	-0.0001850	1.3720315	9.0626010	9.0626010	C
0.00003250	950.2337747	29237962.	9.9694381	0.0003240	-0.0001960	1.4079038	9.3207955	9.3207955	C
0.00003375	982.4744528	29110354.	9.8664221	0.0003330	-0.0002070	1.4435248	9.5784607	9.5784607	C
0.00003500	1015.	28989458.	9.7702529	0.0003420	-0.0002180	1.4788972	9.8356068	9.8356068	C
0.00003625	1047.	28875826.	9.6805768	0.0003509	-0.0002291	1.5140727	10.0926065	10.0926065	C
0.00003750	1079.	28767099.	9.5962346	0.0003599	-0.0002401	1.5489765	10.3489052	10.3489052	C
0.00003875	1111.	28664976.	9.5173690	0.0003688	-0.0002512	1.5837100	10.6052435	10.6052435	C
0.00004000	1143.	28567021.	9.4428739	0.0003777	-0.0002623	1.6181807	10.8609338	10.8609338	C
0.00004125	1175.	28474697.	9.3729516	0.0003866	-0.0002734	1.6524859	11.1166935	11.1166935	C
0.00004250	1206.	28386182.	9.3067346	0.0003955	-0.0002845	1.6865493	11.3719506	11.3719506	C
0.00004375	1238.	28302133.	9.2442484	0.0004044	-0.0002956	1.7204295	11.6271402	11.6271402	C
0.00004500	1270.	28222127.	9.1851552	0.0004133	-0.0003067	1.7541222	11.8822277	11.8822277	C
0.00004625	1302.	28145192.	9.1289350	0.0004222	-0.0003178	1.7875845	12.1368842	12.1368842	C
0.00004750	1333.	28072042.	9.0757231	0.0004311	-0.0003289	1.8208822	12.3916087	12.3916087	C

0.00004875	1365.	28002083.	9.0251630	0.0004400	-0.0003400	1.8539924	12.6462244	12.6462244	C
0.00005125	1428.	27870302.	8.9310154	0.0004577	-0.0003623	1.9196113	13.1548217	13.1548217	C
0.00005375	1492.	27749223.	8.8455166	0.0004754	-0.0003846	1.9845171	13.6632492	13.6632492	C
0.00005625	1555.	27637169.	8.7673994	0.0004932	-0.0004068	2.0486871	14.1713205	14.1713205	C
0.00005875	1618.	27533411.	8.6958940	0.0005109	-0.0004291	2.1121592	14.6793296	14.6793296	C
0.00006125	1680.	27436597.	8.6300227	0.0005286	-0.0004514	2.1748971	15.1869781	15.1869781	C
0.00006375	1743.	27346597.	8.5694644	0.0005463	-0.0004737	2.2369788	15.6948974	15.6948974	C
0.00006625	1806.	27261959.	8.5132401	0.0005640	-0.0004960	2.2983163	16.2023627	16.2023627	C
0.00006875	1869.	27182625.	8.4611697	0.0005817	-0.0005183	2.3589806	16.7099573	16.7099573	C
0.00007125	1931.	27108160.	8.4128851	0.0005994	-0.0005406	2.4189881	17.2178241	17.2178241	C
0.00007375	1994.	27037653.	8.3677410	0.0006171	-0.0005629	2.4782729	17.7254062	17.7254062	C
0.00007625	2057.	26970962.	8.3255828	0.0006348	-0.0005852	2.5368755	18.2330451	18.2330451	C
0.00007875	2119.	26907871.	8.2862213	0.0006525	-0.0006075	2.5948201	18.7409581	18.7409581	C
0.00008125	2181.	26848048.	8.2493987	0.0006703	-0.0006297	2.6521059	19.2491459	19.2491459	C
0.00008375	2244.	26790916.	8.2146822	0.0006880	-0.0006520	2.7086764	19.7571097	19.7571097	C
0.00008625	2306.	26736417.	8.1820164	0.0007057	-0.0006743	2.7645674	20.2651687	20.2651687	C
0.00008875	2368.	26684423.	8.1512986	0.0007234	-0.0006966	2.8197983	20.7735050	20.7735050	C
0.00009125	2430.	26634728.	8.1223690	0.0007412	-0.0007188	2.8743680	21.2821192	21.2821192	C
0.00009375	2493.	26587145.	8.0950849	0.0007589	-0.0007411	2.9282754	21.7910123	21.7910123	C
0.00009625	2555.	26541408.	8.0692299	0.0007767	-0.0007633	2.9814939	22.2999383	22.2999383	C
0.00009875	2617.	26497340.	8.0446639	0.0007944	-0.0007856	3.0340139	22.8088066	22.8088066	C
0.0001013	2679.	26454948.	8.0214070	0.0008122	-0.0008078	3.0858702	23.3179565	23.3179565	C
0.0001038	2740.	26414112.	7.9993648	0.0008299	-0.0008301	3.1370616	-23.8312110	-23.8312110	C
0.0001063	2802.	26374719.	7.9784518	0.0008477	-0.0008523	3.1875871	-24.4698951	-24.4698951	C
0.0001088	2864.	26336669.	7.9585905	0.0008655	-0.0008745	3.2374455	-25.1082950	-25.1082950	C
0.0001113	2926.	26299869.	7.9397101	0.0008833	-0.0008967	3.2866359	-25.7464098	-25.7464098	C
0.0001138	2988.	26264238.	7.9217464	0.0009011	-0.0009189	3.3351570	-26.3842387	-26.3842387	C
0.0001163	3049.	26229578.	7.9045112	0.0009189	-0.0009411	3.3829674	-27.0222163	-27.0222163	C
0.0001188	3111.	26195933.	7.8880714	0.0009367	-0.0009633	3.4301032	-27.6599536	-27.6599536	C
0.0001213	3172.	26163252.	7.8723919	0.0009545	-0.0009855	3.4765680	-28.2974015	-28.2974015	C
0.0001238	3234.	26131474.	7.8574269	0.0009724	-0.0010076	3.5223606	-28.9345590	-28.9345590	C
0.0001263	3295.	26100546.	7.8431340	0.0009902	-0.0010298	3.5674800	-29.5714253	-29.5714253	C
0.0001288	3357.	26070417.	7.8294745	0.0010080	-0.0010520	3.6119249	-30.2079994	-30.2079994	C
0.0001313	3418.	26041039.	7.8164123	0.0010259	-0.0010741	3.6556943	-30.8442805	-30.8442805	C
0.0001338	3479.	26012370.	7.8039141	0.0010438	-0.0010962	3.6987870	-31.4802677	-31.4802677	C
0.0001363	3540.	25984370.	7.7919493	0.0010617	-0.0011183	3.7412019	-32.1159600	-32.1159600	C
0.0001388	3602.	25957002.	7.7804891	0.0010795	-0.0011405	3.7829379	-32.7513566	-32.7513566	C
0.0001413	3663.	25930230.	7.7695070	0.0010974	-0.0011626	3.8239938	-33.3864565	-33.3864565	C
0.0001438	3724.	25904017.	7.7589695	0.0011154	-0.0011846	3.8643657	-34.0212955	-34.0212955	C
0.0001463	3785.	25878287.	7.7487841	0.0011333	-0.0012067	3.9040298	-34.6561689	-34.6561689	C
0.0001488	3846.	25853067.	7.7390109	0.0011512	-0.0012288	3.9430114	-35.2907414	-35.2907414	C
0.0001588	4089.	25756786.	7.7036541	0.0012230	-0.0013170	4.0920905	-37.8260022	-37.8260022	C
0.0001688	4331.	25666842.	7.6734875	0.0012949	-0.0014051	4.2301564	-40.3563701	-40.3563701	C
0.0001788	4573.	25582117.	7.6476523	0.0013670	-0.0014930	4.3571319	-42.8817817	-42.8817817	C

0.0001888	4813.	25501729.	7.6254720	0.0014393	-0.0015807	4.4729382	-45.4021721	-45.4021721	C
0.0001988	5053.	25424972.	7.6064063	0.0015118	-0.0016682	4.5774950	-47.9174749	-47.9174749	C
0.0002088	5291.	25345150.	7.5892813	0.0015843	-0.0017557	4.6705328	-50.0000000	-50.0000000	CY
0.0002188	5504.	25161726.	7.5628455	0.0016544	-0.0018456	4.7494963	-50.0000000	-50.0000000	CY
0.0002288	5681.	24836948.	7.5219802	0.0017207	-0.0019393	4.8141745	-50.0000000	-50.0000000	CY
0.0002388	5836.	24442126.	7.4774389	0.0017852	-0.0020348	4.8679088	50.0000000	50.0000000	CY
0.0002488	5964.	23974877.	7.4379374	0.0018502	-0.0021298	4.9127227	50.0000000	50.0000000	CY
0.0002588	6071.	23460960.	7.4038817	0.0019158	-0.0022242	4.9485822	50.0000000	50.0000000	CY
0.0002688	6162.	22927480.	7.3741204	0.0019818	-0.0023182	4.9751683	50.0000000	50.0000000	CY
0.0002788	6242.	22392762.	7.3469950	0.0020480	-0.0024120	4.9922104	50.0000000	50.0000000	CY
0.0002888	6313.	21862395.	7.3219248	0.0021142	-0.0025058	4.9996434	50.0000000	50.0000000	CY
0.0002988	6376.	21342527.	7.2991891	0.0021806	-0.0025994	4.9999921	50.0000000	50.0000000	CY
0.0003088	6433.	20835389.	7.2782656	0.0022472	-0.0026928	4.9986502	50.0000000	50.0000000	CY
0.0003188	6484.	20342383.	7.2585794	0.0023137	-0.0027863	4.9993117	50.0000000	50.0000000	CY
0.0003288	6531.	19865015.	7.2405470	0.0023803	-0.0028797	4.9996404	50.0000000	50.0000000	CY
0.0003388	6573.	19403041.	7.2241611	0.0024472	-0.0029728	4.9997787	50.0000000	50.0000000	CY
0.0003488	6611.	18956917.	7.2091534	0.0025142	-0.0030658	4.9998034	50.0000000	50.0000000	CY
0.0003588	6646.	18526607.	7.1953802	0.0025813	-0.0031587	4.9997309	50.0000000	50.0000000	CY
0.0003688	6679.	18111962.	7.1827123	0.0026486	-0.0032514	4.9995141	50.0000000	50.0000000	CY
0.0003788	6708.	17712184.	7.1712676	0.0027161	-0.0033439	4.9990482	50.0000000	50.0000000	CY
0.0003888	6736.	17326772.	7.1610679	0.0027839	-0.0034361	4.9981697	50.0000000	50.0000000	CY
0.0003988	6761.	16955282.	7.1513850	0.0028516	-0.0035284	4.9966239	50.0000000	50.0000000	CY
0.0004088	6784.	16597133.	7.1427761	0.0029196	-0.0036204	4.9999479	50.0000000	50.0000000	CY
0.0004188	6806.	16252198.	7.1351815	0.0029879	-0.0037121	4.9992657	50.0000000	50.0000000	CY
0.0004288	6826.	15919870.	7.1280649	0.0030562	-0.0038038	4.9974681	50.0000000	50.0000000	CY
0.0004388	6844.	15598756.	7.1218780	0.0031247	-0.0038953	4.9999951	50.0000000	50.0000000	CY
0.0004488	6861.	15290102.	7.1162356	0.0031934	-0.0039866	4.9990930	50.0000000	50.0000000	CY
0.0004588	6877.	14990892.	7.1111795	0.0032623	-0.0040777	4.9962492	50.0000000	50.0000000	CY
0.0004688	6892.	14703332.	7.1066695	0.0033313	-0.0041687	4.9997415	50.0000000	50.0000000	CY
0.0004788	6906.	14424612.	7.1028004	0.0034005	-0.0042595	4.9973063	50.0000000	50.0000000	CY
0.0004888	6919.	14156304.	7.0994378	0.0034699	-0.0043501	4.9999357	50.0000000	50.0000000	CY
0.0004988	6931.	13896262.	7.0964380	0.0035393	-0.0044407	4.9976349	50.0000000	50.0000000	CY
0.0005088	6942.	13645504.	7.0941942	0.0036092	-0.0045308	4.9999642	50.0000000	50.0000000	CY
0.0005188	6953.	13402597.	7.0918160	0.0036789	-0.0046211	4.9973517	50.0000000	50.0000000	CY
0.0005288	6962.	13167518.	7.0904337	0.0037491	-0.0047109	4.9998975	50.0000000	50.0000000	CY
0.0005388	6972.	12940190.	7.0891081	0.0038193	-0.0048007	4.9963784	50.0000000	50.0000000	CY

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	122.800	6809.170	0.00300000

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	6809.	79.820000	4426.	25633629.
1	0.70	6809.	85.960000	4766.	25517440.
1	0.75	6809.	92.100000	5107.	25406942.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	2963361.
2	62.0000	62.0000	No	No	2963361.	0.00

```
  3       69.0000     69.0000      No          No           0.00      N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
       for Layer n. Layering correction equivalent depths are computed only
       for soil types with both shallow-depth and deep-depth expressions for
       peak lateral load transfer. These soil types are soft and stiff clays,
       non-liquefied sands, and cemented c-phi soil.
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                             =      20230.0 lbs
Applied moment at pile head                          =          0.0 in-lbs
Axial thrust load on pile head                       =     122800.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7395	-4.02E-07	20230.	-0.00685	0.00	3.26E+10	0.00	0.00	0.00
0.5000	0.6984	126428.	20146.	-0.00684	0.00	3.26E+10	-28.1199	241.5956	0.00
1.0000	0.6574	251827.	19877.	-0.00680	0.00	3.26E+10	-61.5801	562.0445	0.00
1.5000	0.6167	374974.	19403.	-0.00675	0.00	3.26E+10	-96.3519	937.4349	0.00
2.0000	0.5764	494603.	18734.	-0.00667	0.00	3.26E+10	-126.5968	1318.	0.00
2.5000	0.5367	609606.	17897.	-0.00657	0.00	3.26E+10	-152.4658	1705.	0.00
3.0000	0.4976	719038.	16923.	-0.00644	0.00	3.26E+10	-172.0448	2074.	0.00
3.5000	0.4594	822179.	15848.	-0.00629	0.00	2.98E+10	-186.1837	2432.	0.00
4.0000	0.4221	918496.	14699.	-0.00612	0.00	2.94E+10	-196.9887	2800.	0.00
4.5000	0.3860	1007583.	13470.	-0.00592	0.00	2.90E+10	-212.6146	3305.	0.00
5.0000	0.3511	1088862.	12169.	-0.00570	0.00	2.87E+10	-221.0914	3779.	0.00
5.5000	0.3175	1162014.	10821.	-0.00547	0.00	2.85E+10	-228.2024	4312.	0.00
6.0000	0.2855	1226770.	9402.	-0.00521	0.00	2.83E+10	-244.8340	5146.	0.00
6.5000	0.2550	1282522.	7893.	-0.00495	0.00	2.82E+10	-258.2756	6078.	0.00
7.0000	0.2261	1328774.	6301.	-0.00467	0.00	2.81E+10	-272.1477	7222.	0.00
7.5000	0.1989	1365020.	4629.	-0.00438	0.00	2.80E+10	-285.2189	8603.	0.00
8.0000	0.1735	1390782.	2888.	-0.00409	0.00	2.79E+10	-295.1571	10206.	0.00
8.5000	0.1499	1405699.	1098.	-0.00379	0.00	2.79E+10	-301.6684	12075.	0.00

9.0000	0.1281	1409533.	-720.7513	-0.00348	0.00	2.79E+10	-304.5002	14262.	0.00
9.5000	0.1081	1402181.	-2545.	-0.00318	0.00	2.79E+10	-303.4401	16840.	0.00
10.0000	0.08994	1383684.	-4350.	-0.00288	0.00	2.80E+10	-298.3123	19902.	0.00
10.5000	0.07354	1354229.	-6112.	-0.00259	0.00	2.80E+10	-288.9700	23577.	0.00
11.0000	0.05888	1314158.	-7804.	-0.00230	0.00	2.81E+10	-275.2803	28051.	0.00
11.5000	0.04591	1263969.	-9402.	-0.00203	0.00	2.82E+10	-257.0977	33602.	0.00
12.0000	0.03454	1204328.	-10875.	-0.00177	0.00	2.84E+10	-234.2134	40680.	0.00
12.5000	0.02471	1136067.	-12129.	-0.00152	0.00	2.86E+10	-183.4626	44550.	0.00
13.0000	0.01630	1061025.	-13057.	-0.00129	0.00	2.88E+10	-125.8964	46332.	0.00
13.5000	0.00922	981289.	-13656.	-0.00108	0.00	2.91E+10	-73.9631	48114.	0.00
14.0000	0.00336	898741.	-13962.	-8.86E-04	0.00	2.95E+10	-27.9144	49896.	0.00
14.5000	-0.00141	815053.	-14009.	-7.13E-04	0.00	2.99E+10	12.1586	51678.	0.00
15.0000	-0.00520	731682.	-13834.	-5.64E-04	0.00	3.26E+10	46.3078	53460.	0.00
15.5000	-0.00817	649880.	-13469.	-4.36E-04	0.00	3.26E+10	75.2590	55242.	0.00
16.0000	-0.01043	570698.	-12946.	-3.24E-04	0.00	3.26E+10	99.1551	57024.	0.00
16.5000	-0.01206	495008.	-12294.	-2.26E-04	0.00	3.26E+10	118.2166	58806.	0.00
17.0000	-0.01314	423507.	-11541.	-1.41E-04	0.00	3.26E+10	132.7277	60588.	0.00
17.5000	-0.01376	356727.	-10714.	-6.97E-05	0.00	3.26E+10	143.0228	62370.	0.00
18.0000	-0.01398	295047.	-9836.	-9.72E-06	0.00	3.26E+10	149.4737	64152.	0.00
18.5000	-0.01388	238709.	-8930.	3.94E-05	0.00	3.26E+10	152.4779	65934.	0.00
19.0000	-0.01351	187827.	-8015.	7.86E-05	0.00	3.26E+10	152.4468	67716.	0.00
19.5000	-0.01293	142408.	-7109.	1.09E-04	0.00	3.26E+10	149.7962	69498.	0.00
20.0000	-0.01220	102362.	-6224.	1.31E-04	0.00	3.26E+10	144.9368	71280.	0.00
20.5000	-0.01135	67520.	-5375.	1.47E-04	0.00	3.26E+10	138.2669	73062.	0.00
21.0000	-0.01043	37647.	-4570.	1.57E-04	0.00	3.26E+10	130.1655	74844.	0.00
21.5000	-0.00947	12454.	-3816.	1.61E-04	0.00	3.26E+10	120.9870	76626.	0.00
22.0000	-0.00850	-8384.	-3120.	1.62E-04	0.00	3.26E+10	111.0579	78408.	0.00
22.5000	-0.00753	-25224.	-2485.	1.59E-04	0.00	3.26E+10	100.6732	80190.	0.00
23.0000	-0.00659	-38436.	-1912.	1.53E-04	0.00	3.26E+10	90.0951	81972.	0.00
23.5000	-0.00570	-48399.	-1404.	1.45E-04	0.00	3.26E+10	79.5520	83754.	0.00
24.0000	-0.00486	-55492.	-957.1798	1.35E-04	0.00	3.26E+10	69.2382	85536.	0.00
24.5000	-0.00408	-60084.	-571.5189	1.25E-04	0.00	3.26E+10	59.3154	87318.	0.00
25.0000	-0.00336	-62534.	-243.8325	1.13E-04	0.00	3.26E+10	49.9134	89100.	0.00
25.5000	-0.00272	-63177.	29.3042	1.02E-04	0.00	3.26E+10	41.1322	90882.	0.00
26.0000	-0.00214	-62332.	251.8334	9.03E-05	0.00	3.26E+10	33.0442	92664.	0.00
26.5000	-0.00163	-60288.	428.0568	7.90E-05	0.00	3.26E+10	25.6969	94446.	0.00
27.0000	-0.00119	-57312.	562.4941	6.82E-05	0.00	3.26E+10	19.1155	96228.	0.00
27.5000	-8.15E-04	-53639.	659.7569	5.80E-05	0.00	3.26E+10	13.3055	98010.	0.00
28.0000	-4.96E-04	-49480.	724.4407	4.85E-05	0.00	3.26E+10	8.2558	99792.	0.00
28.5000	-2.33E-04	-45017.	761.0329	3.98E-05	0.00	3.26E+10	3.9416	101574.	0.00
29.0000	-1.90E-05	-40406.	773.8373	3.19E-05	0.00	3.26E+10	0.3266	103356.	0.00
29.5000	1.50E-04	-35778.	766.9147	2.49E-05	0.00	3.26E+10	-2.6341	105138.	0.00
30.0000	2.80E-04	-31240.	744.0371	1.88E-05	0.00	3.26E+10	-4.9918	106920.	0.00
30.5000	3.75E-04	-26877.	708.6560	1.34E-05	0.00	3.26E+10	-6.8019	108702.	0.00

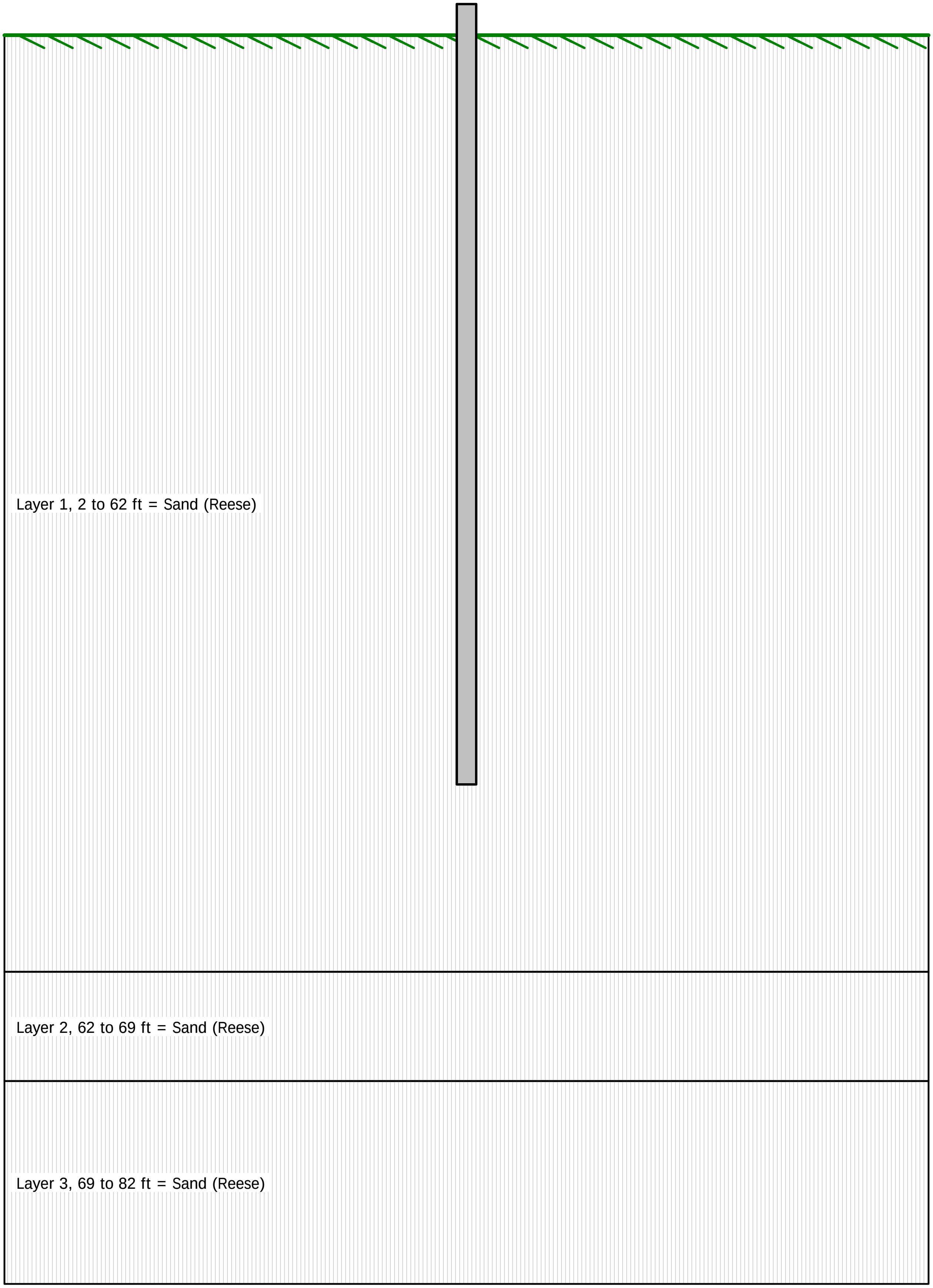
31.0000	4.41E-04	-22756.	663.8827	8.85E-06	0.00	3.26E+10	-8.1225	110484.	0.00
31.5000	4.82E-04	-18924.	612.4784	5.02E-06	0.00	3.26E+10	-9.0122	112266.	0.00
32.0000	5.01E-04	-15414.	556.8544	1.86E-06	0.00	3.26E+10	-9.5291	114048.	0.00
32.5000	5.04E-04	-12244.	499.0793	-6.83E-07	0.00	3.26E+10	-9.7293	115830.	0.00
33.0000	4.93E-04	-9424.	440.8930	-2.68E-06	0.00	3.26E+10	-9.6661	117612.	0.00
33.5000	4.72E-04	-6950.	383.7257	-4.18E-06	0.00	3.26E+10	-9.3896	119394.	0.00
34.0000	4.43E-04	-4813.	328.7201	-5.26E-06	0.00	3.26E+10	-8.9456	121176.	0.00
34.5000	4.09E-04	-2997.	276.7566	-5.98E-06	0.00	3.26E+10	-8.3755	122958.	0.00
35.0000	3.71E-04	-1483.	228.4808	-6.39E-06	0.00	3.26E+10	-7.7164	124740.	0.00
35.5000	3.32E-04	-246.0212	184.3304	-6.55E-06	0.00	3.26E+10	-7.0004	126522.	0.00
36.0000	2.93E-04	738.7980	144.5629	-6.51E-06	0.00	3.26E+10	-6.2554	128304.	0.00
36.5000	2.54E-04	1498.	109.2830	-6.30E-06	0.00	3.26E+10	-5.5046	130086.	0.00
37.0000	2.17E-04	2059.	78.4677	-5.97E-06	0.00	3.26E+10	-4.7672	131868.	0.00
37.5000	1.82E-04	2449.	51.9908	-5.56E-06	0.00	3.26E+10	-4.0584	133650.	0.00
38.0000	1.50E-04	2692.	29.6454	-5.09E-06	0.00	3.26E+10	-3.3901	135432.	0.00
38.5000	1.21E-04	2812.	11.1634	-4.58E-06	0.00	3.26E+10	-2.7706	137214.	0.00
39.0000	9.52E-05	2832.	-3.7658	-4.06E-06	0.00	3.26E+10	-2.2058	138996.	0.00
39.5000	7.24E-05	2773.	-15.4799	-3.55E-06	0.00	3.26E+10	-1.6989	140778.	0.00
40.0000	5.27E-05	2652.	-24.3301	-3.05E-06	0.00	3.26E+10	-1.2512	142560.	0.00
40.5000	3.58E-05	2485.	-30.6700	-2.58E-06	0.00	3.26E+10	-0.8621	144342.	0.00
41.0000	2.18E-05	2287.	-34.8459	-2.14E-06	0.00	3.26E+10	-0.5299	146124.	0.00
41.5000	1.02E-05	2070.	-37.1898	-1.74E-06	0.00	3.26E+10	-0.2515	147906.	0.00
42.0000	9.30E-07	1844.	-38.0138	-1.38E-06	0.00	3.26E+10	-0.02320	149688.	0.00
42.5000	-6.31E-06	1616.	-37.6059	-1.06E-06	0.00	3.26E+10	0.1592	151470.	0.00
43.0000	-1.18E-05	1394.	-36.2273	-7.81E-07	0.00	3.26E+10	0.3003	153252.	0.00
43.5000	-1.57E-05	1183.	-34.1114	-5.44E-07	0.00	3.26E+10	0.4050	155034.	0.00
44.0000	-1.83E-05	985.5277	-31.4631	-3.44E-07	0.00	3.26E+10	0.4778	156816.	0.00
44.5000	-1.98E-05	805.5366	-28.4593	-1.79E-07	0.00	3.26E+10	0.5235	158598.	0.00
45.0000	-2.04E-05	644.2808	-25.2502	-4.62E-08	0.00	3.26E+10	0.5462	160380.	0.00
45.5000	-2.04E-05	502.6024	-21.9609	5.93E-08	0.00	3.26E+10	0.5502	162162.	0.00
46.0000	-1.97E-05	380.6627	-18.6935	1.41E-07	0.00	3.26E+10	0.5389	163944.	0.00
46.5000	-1.87E-05	278.0731	-15.5296	2.01E-07	0.00	3.26E+10	0.5157	165726.	0.00
47.0000	-1.73E-05	194.0110	-12.5327	2.45E-07	0.00	3.26E+10	0.4833	167508.	0.00
47.5000	-1.57E-05	127.3206	-9.7509	2.74E-07	0.00	3.26E+10	0.4440	169290.	0.00
48.0000	-1.40E-05	76.5968	-7.2195	2.93E-07	0.00	3.26E+10	0.3998	171072.	0.00
48.5000	-1.22E-05	40.2548	-4.9638	3.04E-07	0.00	3.26E+10	0.3521	172854.	0.00
49.0000	-1.04E-05	16.5833	-3.0013	3.09E-07	0.00	3.26E+10	0.3021	174636.	0.00
49.5000	-8.52E-06	3.7845	-1.3438	3.11E-07	0.00	3.26E+10	0.2504	176418.	0.00
50.0000	-6.65E-06	0.00	0.00	3.11E-07	0.00	3.26E+10	0.1975	89100.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be inter-

```
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.73946358 inches
Computed slope at pile head      =    -0.00685140 radians
Maximum bending moment           =       1409533. inch-lbs
Maximum shear force              =         20230. lbs
Depth of maximum bending moment  =     9.00000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             13
Number of zero deflection points =              3


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                  Axial    Pile-head  Pile-head  Max Shear Max Moment
Case Type   Pile-head    Type      Pile-head  Loading  Deflection  Rotation    in Pile    in Pile
 No.  1      Load 1       2         Load 2      lbs      inches     radians      lbs      in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
  1  V, lb     20230.  M, in-lb        0.00    122800.     0.7395   -0.00685     20230.   1409533.


Maximum pile-head deflection = 0.7394635816 inches
Maximum pile-head rotation   = -0.0068514027 radians = -0.392556 deg.

The analysis ended normally.
```

Pier HP Pile

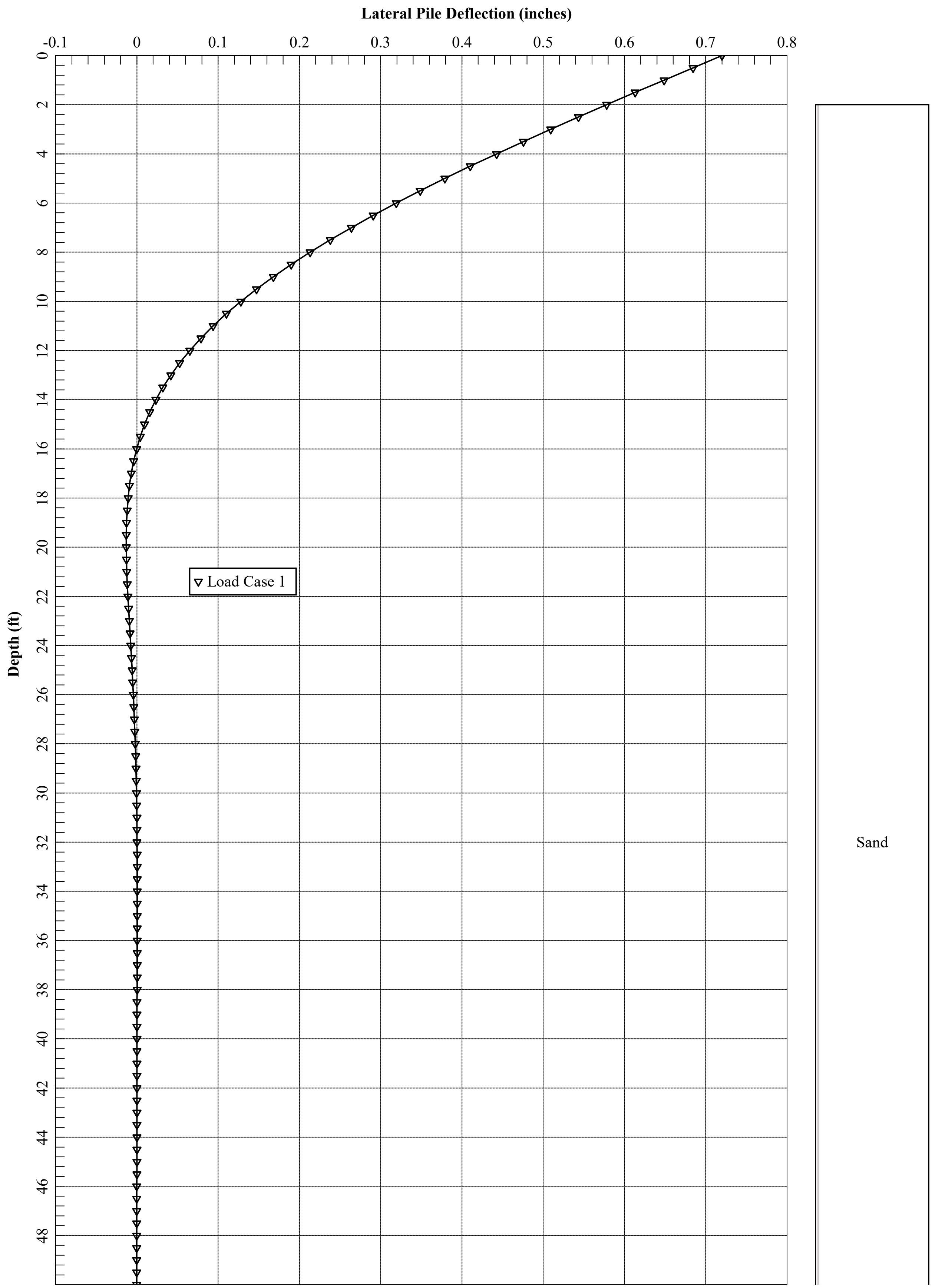
Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



LPile 2018.10.09, © 2018 by Ensoft, Inc.

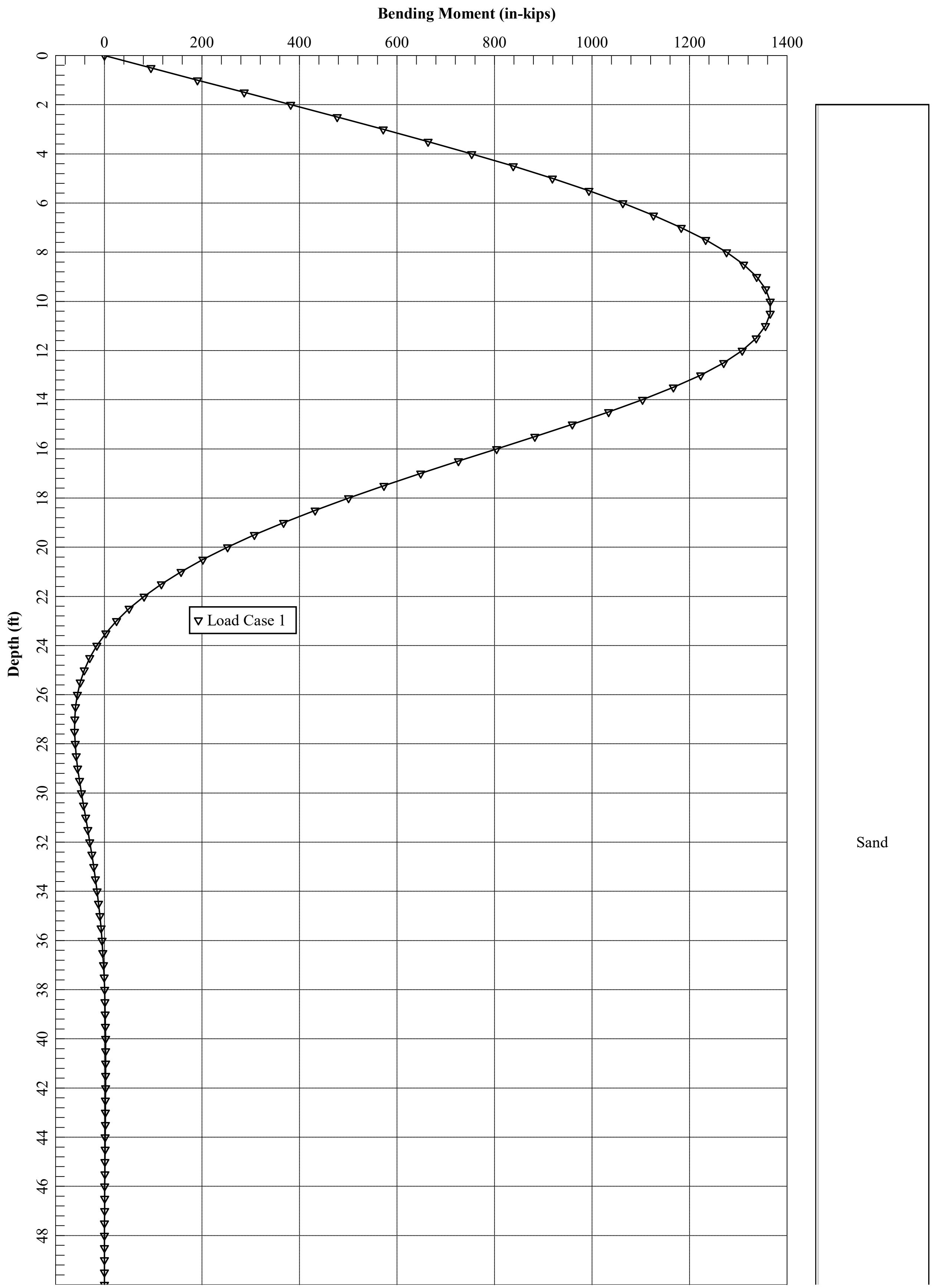
Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



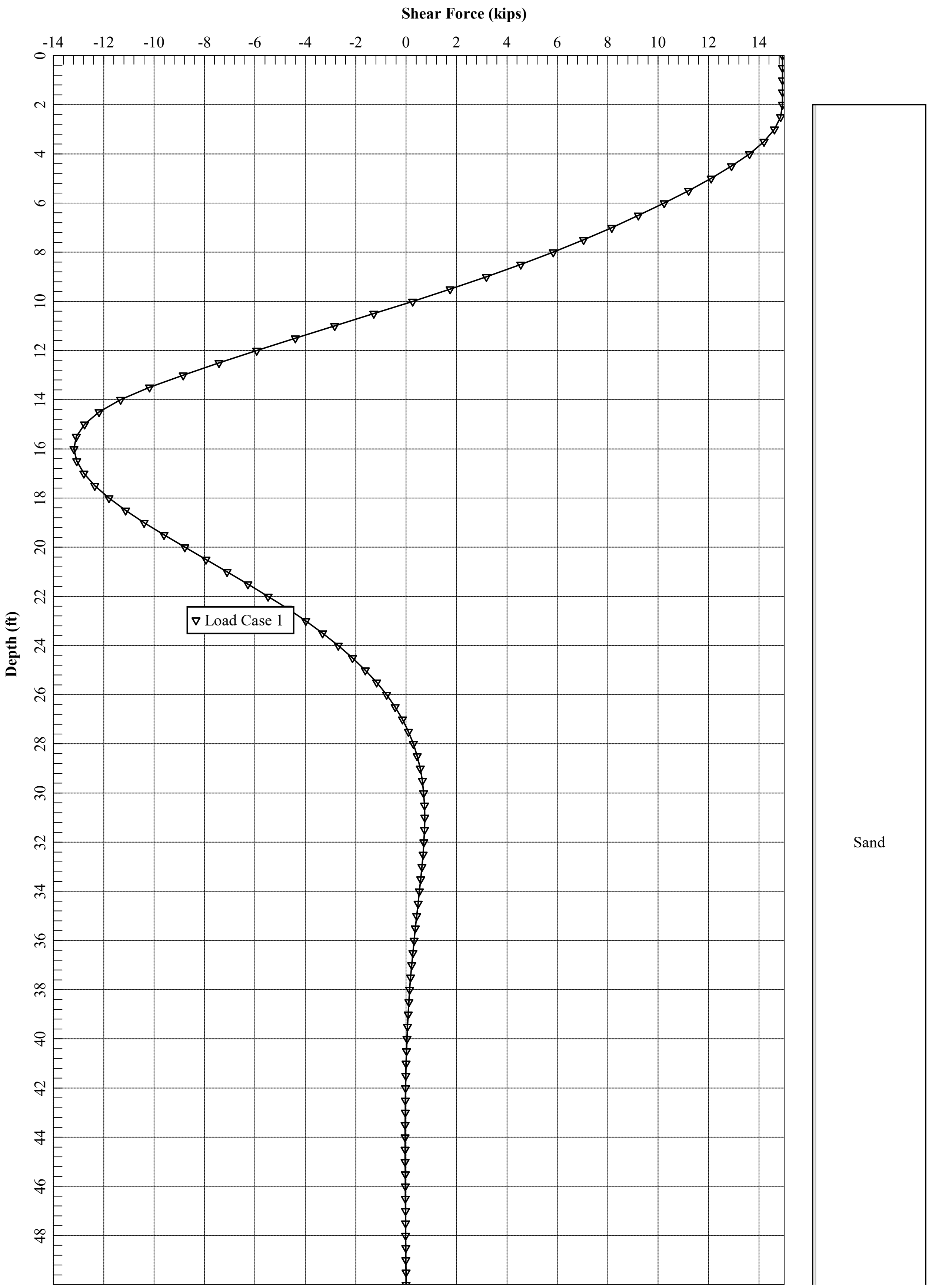
Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



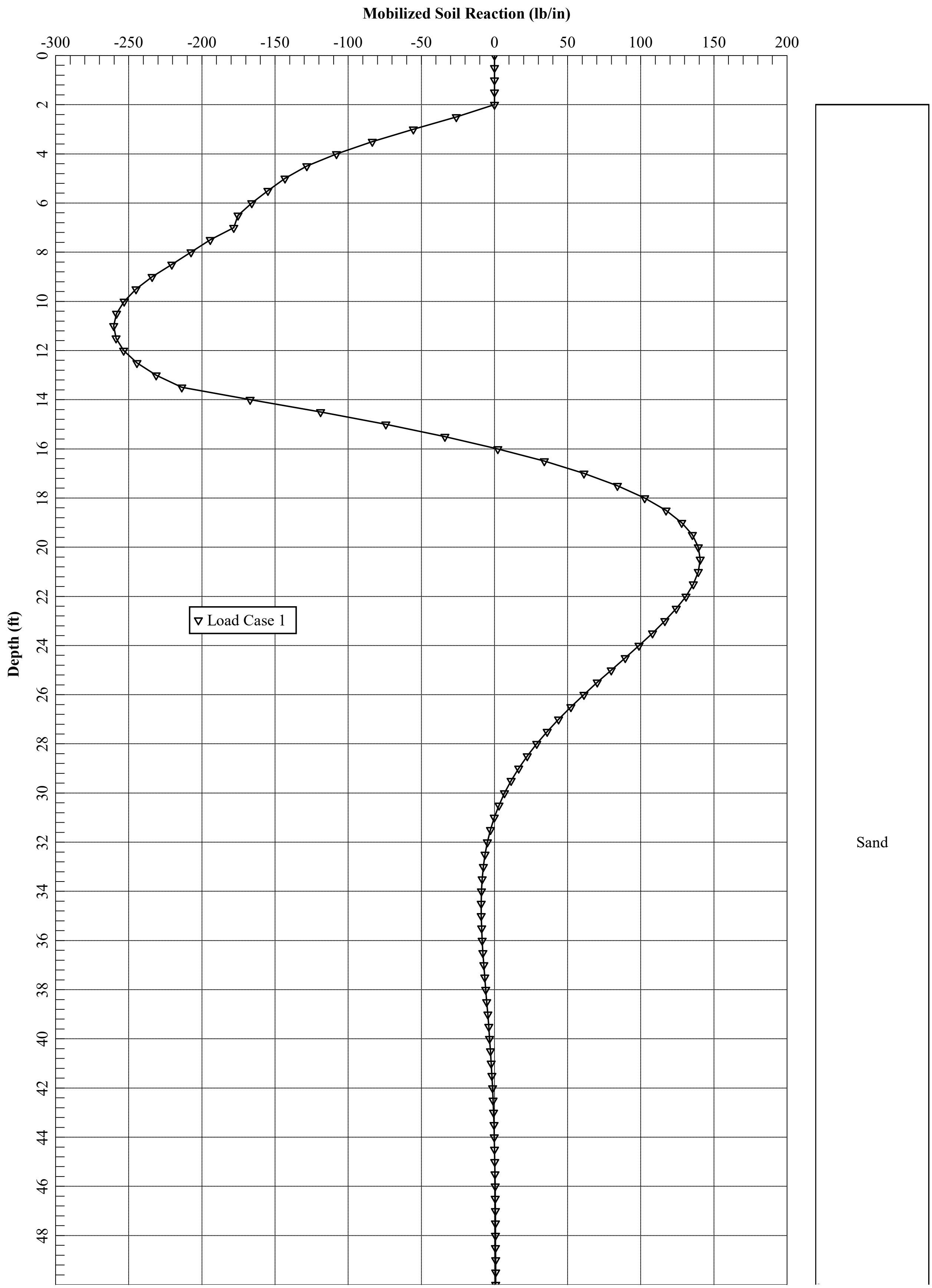
Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches

```
================================================================================

                  LPile for Windows(Beta), Version 2018-10.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                                     Files Used for Analysis
       --------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name of input data file:
2. Pier HP Pile.lp10

Name of output report file:
2. Pier HP Pile.lp10

Name of plot output file:
2. Pier HP Pile.lp10

Name of runtime message file:
2. Pier HP Pile.lp10
```

```
--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

              Date:  March 27, 2020             Time:  10:10:50


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment



--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified
```

```
 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                         =            1
Total length of pile                                    =       50.000 ft
Depth of ground surface below top of pile               =       2.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           14.9000
  2           50.000           14.9000


Input Structural Properties for Pile Sections:
```

```
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                =    50.000000 ft
   Pile width                                       =    14.900000 in
   Shear capacity of section                        =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =     2.000000 ft
   Distance from top of pile to bottom of layer     =    62.000000 ft
   Effective unit weight at top of layer            =    57.600000 pcf
   Effective unit weight at bottom of layer         =    57.600000 pcf
   Friction angle at top of layer                   =    32.000000 deg.
   Friction angle at bottom of layer                =    32.000000 deg.
   Subgrade k at top of layer                       =    55.000000 pci
   Subgrade k at bottom of layer                    =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =    62.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
   Distance from top of pile to bottom of layer        =    82.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =   120.000000 pci
   Subgrade k at bottom of layer                       =   120.000000 pci


 (Depth of the lowest soil layer extends 32.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
Layer           Name             Depth      Unit Wt.     Friction        kpy
 Num.     (p-y Curve Type)        ft          pcf          deg.          pci
-----    -------------------   ----------   ----------   ----------   ----------
  1            Sand               2.0000      57.6000      32.0000      55.0000
          (Reese, et al.)        62.0000      57.6000      32.0000      55.0000
  2            Sand              62.0000      67.6000      35.0000      86.0000
          (Reese, et al.)        69.0000      67.6000      35.0000      86.0000
  3            Sand              69.0000      72.6000      38.0000     120.0000
          (Reese, et al.)        82.0000      72.6000      38.0000     120.0000


--------------------------------------------------------------------------------
                    p-y Modification Factors for Group Action
--------------------------------------------------------------------------------
```

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	2.000	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4	y = 0.720000 in	M = 0.0000 in-lbs	166100.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

```
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Strong Axis:
---------------------------------------------

Length of Section                                      =    50.000000 ft
Flange Width                                           =    14.900000 in
Section Depth                                          =    14.200000 in
Flange Thickness                                       =     0.805000 in
Web Thickness                                          =     0.805000 in
Yield Stress of Pipe                                   =    50.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    34.123950 sq. in.
Moment of Inertia                                      =        1211. in^4
Elastic Bending Stiffness                              =    35125694. kip-in^2
Plastic Modulus, Z                                     =   192.566083in^3
Plastic Moment Capacity = Fy Z                         =        9628.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =     1706.197 kips
Nominal Axial Tensile Capacity                         =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1             166.100

Definition of Run Messages:

   Y = part of pipe section has yielded.
```

Axial Thrust Force = 166.100 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000464	162.7359835	35100995.	43.3033008	5.8126011	
0.00000927	325.4719670	35100995.	25.2016504	6.7576530	
0.00001391	488.2079505	35100995.	19.1677669	7.7027051	
0.00001854	650.9439340	35100995.	16.1508252	8.6477571	
0.00002318	813.6799175	35100995.	14.3406602	9.5928091	
0.00002782	976.4159011	35100995.	13.1338835	10.5378612	
0.00003245	1139.	35100995.	12.2719001	11.4829132	
0.00003709	1302.	35100995.	11.6254126	12.4279652	
0.00004173	1465.	35100995.	11.1225890	13.3730172	
0.00004636	1627.	35100995.	10.7203301	14.3180693	
0.00005100	1790.	35100995.	10.3912092	15.2631213	
0.00005563	1953.	35100995.	10.1169417	16.2081733	
0.00006027	2116.	35100995.	9.8848693	17.1532253	
0.00006491	2278.	35100995.	9.6859501	18.0982774	
0.00006954	2441.	35100995.	9.5135534	19.0433294	
0.00007418	2604.	35100995.	9.3627063	19.9883814	
0.00007882	2767.	35100995.	9.2296059	20.9334334	
0.00008345	2929.	35100995.	9.1112945	21.8784855	
0.00008809	3092.	35100995.	9.0054369	22.8235375	
0.00009272	3255.	35100995.	8.9101650	23.7685895	
0.00009736	3417.	35100995.	8.8239667	24.7136415	
0.0001020	3580.	35100995.	8.7456046	25.6586935	
0.0001066	3743.	35100995.	8.6740566	26.6037456	
0.0001113	3906.	35100995.	8.6084709	27.5487976	
0.0001159	4068.	35100995.	8.5481320	28.4938496	
0.0001205	4231.	35100995.	8.4924346	29.4389016	
0.0001252	4394.	35100995.	8.4408630	30.3839537	
0.0001298	4557.	35100995.	8.3929750	31.3290057	
0.0001345	4719.	35100995.	8.3483897	32.2740577	
0.0001391	4882.	35100995.	8.3067767	33.2191097	
0.0001437	5045.	35100995.	8.2678484	34.1641618	
0.0001484	5208.	35100995.	8.2313532	35.1092138	
0.0001530	5370.	35100995.	8.1970697	36.0542658	
0.0001576	5533.	35100995.	8.1648030	36.9993178	
0.0001623	5696.	35100995.	8.1343800	37.9443698	
0.0001669	5858.	35100995.	8.1056472	38.8894219	

Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches

0.0001715	6021.	35100995.	8.0784676	39.8344739	
0.0001762	6184.	35100995.	8.0527184	40.7795259	
0.0001808	6347.	35100995.	8.0282898	41.7245779	
0.0001901	6672.	35100995.	7.9830073	43.6146820	
0.0001994	6998.	35100995.	7.9419372	45.5047860	
0.0002086	7323.	35100995.	7.9045178	47.3948901	
0.0002179	7649.	35100995.	7.8702830	49.2849941	
0.0002272	7950.	34995721.	7.8540420	50.0000000	Y
0.0002364	8175.	34574208.	7.8870509	50.0000000	Y
0.0002457	8301.	33782029.	7.9793307	50.0000000	Y
0.0002550	8396.	32927515.	8.0837199	50.0000000	Y
0.0002643	8485.	32106540.	8.1851565	50.0000000	Y
0.0002735	8567.	31318147.	8.2836741	50.0000000	Y
0.0002828	8643.	30561645.	8.3792485	50.0000000	Y
0.0002921	8714.	29835633.	8.4719742	50.0000000	Y
0.0003014	8781.	29138830.	8.5619263	50.0000000	Y
0.0003106	8844.	28470055.	8.6491623	50.0000000	Y
0.0003199	8902.	27827245.	8.7330580	50.0000000	Y
0.0003292	8953.	27198453.	8.8069420	50.0000000	Y
0.0003384	9000.	26593579.	8.8768847	50.0000000	Y
0.0003477	9042.	26003928.	8.9378853	50.0000000	Y
0.0003570	9080.	25435938.	8.9946017	50.0000000	Y
0.0003663	9114.	24882952.	9.0424503	50.0000000	Y
0.0003755	9144.	24348373.	9.0853846	50.0000000	Y
0.0003848	9169.	23827650.	9.1190575	50.0000000	Y
0.0003941	9190.	23321194.	9.1441461	50.0000000	Y
0.0004034	9208.	22827723.	9.1602639	50.0000000	Y
0.0004126	9219.	22343397.	9.1633431	50.0000000	Y
0.0004219	9230.	21876613.	9.1633967	50.0000000	Y
0.0004312	9239.	21428326.	9.1633021	50.0000000	Y
0.0004404	9248.	20997294.	9.1633647	50.0000000	Y
0.0004497	9257.	20583405.	9.1633565	50.0000000	Y
0.0004590	9264.	20184379.	9.1633464	50.0000000	Y
0.0004683	9272.	19800860.	9.1634274	50.0000000	Y
0.0004775	9279.	19430719.	9.1633414	50.0000000	Y
0.0004868	9286.	19074485.	9.1634326	50.0000000	Y
0.0004961	9292.	18730197.	9.1633497	50.0000000	Y
0.0005053	9298.	18398538.	9.1632801	50.0000000	Y
0.0005146	9303.	18077537.	9.1633714	50.0000000	Y
0.0005239	9308.	17767812.	9.1632940	50.0000000	Y
0.0005332	9313.	17468162.	9.1634069	50.0000000	Y
0.0005424	9318.	17178234.	9.1633315	50.0000000	Y
0.0005517	9323.	16898017.	9.1633310	50.0000000	Y
0.0005888	9339.	15860447.	9.1633798	50.0000000	Y

0.0006259	9352.	14941699.	9.1633315	50.0000000	Y
0.0006630	9363.	14122530.	9.1633103	50.0000000	Y
0.0007001	9372.	13387675.	9.1633152	50.0000000	Y
0.0007372	9380.	12724886.	9.1633464	50.0000000	Y
0.0007742	9387.	12124211.	9.1634052	50.0000000	Y
0.0008113	9393.	11577470.	9.1634937	50.0000000	Y
0.0008484	9398.	11077283.	9.1632973	50.0000000	Y
0.0008855	9403.	10618456.	9.1634223	50.0000000	Y
0.0009226	9407.	10195985.	9.1632445	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	166.1000000000	9407.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head	Equivalent Top Depth Below Grnd Surf	Same Layer Type As Layer	Layer is Rock or is Below	F0 Integral for Layer	F1 Integral for Layer

Pier HP Pile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches

	ft	ft	Above	Rock Layer	lbs	lbs
1	2.0000	0.00	N.A.	No	0.00	2550692.
2	62.0000	60.0000	No	No	2550692.	0.00
3	69.0000	67.0000	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.720000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 166100.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7200	0.00	14936.	-0.00595	4868.	3.51E+10	0.00	0.00	0.00
0.5000	0.6843	95546.	14936.	-0.00594	5455.	3.51E+10	0.00	0.00	0.00
1.0000	0.6487	191076.	14936.	-0.00592	6043.	3.51E+10	0.00	0.00	0.00
1.5000	0.6133	286574.	14936.	-0.00588	6630.	3.51E+10	0.00	0.00	0.00
2.0000	0.5782	382023.	14936.	-0.00582	7217.	3.51E+10	0.00	0.00	0.00
2.5000	0.5434	477406.	14858.	-0.00575	7804.	3.51E+10	-26.0841	287.9885	0.00
3.0000	0.5092	571770.	14613.	-0.00566	8384.	3.51E+10	-55.3872	652.6284	0.00
3.5000	0.4756	664041.	14197.	-0.00555	8952.	3.51E+10	-83.5422	1054.	0.00
4.0000	0.4426	753193.	13622.	-0.00543	9500.	3.51E+10	-107.9540	1463.	0.00
4.5000	0.4104	838329.	12913.	-0.00529	10024.	3.51E+10	-128.2772	1875.	0.00
5.0000	0.3791	918705.	12099.	-0.00514	10518.	3.51E+10	-143.1989	2267.	0.00
5.5000	0.3487	993769.	11205.	-0.00498	10980.	3.51E+10	-154.9073	2666.	0.00
6.0000	0.3193	1063088.	10242.	-0.00480	11406.	3.51E+10	-165.9513	3118.	0.00
6.5000	0.2910	1126250.	9218.	-0.00462	11795.	3.51E+10	-175.2874	3614.	0.00
7.0000	0.2639	1182911.	8158.	-0.00442	12143.	3.51E+10	-178.2569	4053.	0.00

7.5000	0.2380	1232953.	7040.	-0.00421	12451.	3.51E+10	-194.2781	4898.	0.00
8.0000	0.2133	1275791.	5835.	-0.00400	12715.	3.51E+10	-207.3247	5831.	0.00
8.5000	0.1900	1310948.	4552.	-0.00378	12931.	3.51E+10	-220.5701	6966.	0.00
9.0000	0.1680	1337941.	3188.	-0.00355	13097.	3.51E+10	-234.0131	8358.	0.00
9.5000	0.1474	1356281.	1751.	-0.00332	13210.	3.51E+10	-244.9890	9975.	0.00
10.0000	0.1281	1365571.	256.2643	-0.00309	13267.	3.51E+10	-253.2009	11857.	0.00
10.5000	0.1103	1365513.	-1278.	-0.00286	13267.	3.51E+10	-258.3817	14056.	0.00
11.0000	0.09386	1355921.	-2835.	-0.00262	13208.	3.51E+10	-260.2933	16639.	0.00
11.5000	0.07882	1336727.	-4392.	-0.00239	13089.	3.51E+10	-258.7234	19695.	0.00
12.0000	0.06515	1307991.	-5928.	-0.00217	12913.	3.51E+10	-253.4789	23345.	0.00
12.5000	0.05282	1269908.	-7422.	-0.00195	12678.	3.51E+10	-244.3745	27761.	0.00
13.0000	0.04179	1222810.	-8848.	-0.00173	12389.	3.51E+10	-231.2106	33196.	0.00
13.5000	0.03202	1167181.	-10183.	-0.00153	12047.	3.51E+10	-213.7338	40054.	0.00
14.0000	0.02344	1103658.	-11326.	-0.00134	11656.	3.51E+10	-167.0888	42768.	0.00
14.5000	0.01600	1033932.	-12183.	-0.00115	11227.	3.51E+10	-118.7788	44550.	0.00
15.0000	0.00961	959754.	-12762.	-9.82E-04	10771.	3.51E+10	-74.2356	46332.	0.00
15.5000	0.00421	882740.	-13087.	-8.24E-04	10297.	3.51E+10	-33.7939	48114.	0.00
16.0000	-2.80E-04	804360.	-13181.	-6.80E-04	9815.	3.51E+10	2.3261	49896.	0.00
16.5000	-0.00395	725925.	-13072.	-5.49E-04	9333.	3.51E+10	34.0102	51678.	0.00
17.0000	-0.00687	648592.	-12786.	-4.32E-04	8857.	3.51E+10	61.2399	53460.	0.00
17.5000	-0.00913	573352.	-12350.	-3.28E-04	8394.	3.51E+10	84.0823	55242.	0.00
18.0000	-0.01080	501042.	-11790.	-2.36E-04	7949.	3.51E+10	102.6780	57024.	0.00
18.5000	-0.01196	432343.	-11130.	-1.56E-04	7527.	3.51E+10	117.2299	58806.	0.00
19.0000	-0.01267	367791.	-10395.	-8.76E-05	7130.	3.51E+10	127.9916	60588.	0.00
19.5000	-0.01301	307783.	-9605.	-2.98E-05	6761.	3.51E+10	135.2563	62370.	0.00
20.0000	-0.01303	252593.	-8781.	1.81E-05	6421.	3.51E+10	139.3459	64152.	0.00
20.5000	-0.01279	202376.	-7941.	5.70E-05	6112.	3.51E+10	140.6012	65934.	0.00
21.0000	-0.01235	157186.	-7101.	8.77E-05	5834.	3.51E+10	139.3726	67716.	0.00
21.5000	-0.01174	116986.	-6275.	1.11E-04	5587.	3.51E+10	136.0120	69498.	0.00
22.0000	-0.01102	81664.	-5474.	1.28E-04	5370.	3.51E+10	130.8656	71280.	0.00
22.5000	-0.01021	51038.	-4709.	1.39E-04	5181.	3.51E+10	124.2677	73062.	0.00
23.0000	-0.00934	24877.	-3987.	1.46E-04	5021.	3.51E+10	116.5353	74844.	0.00
23.5000	-0.00845	2908.	-3313.	1.48E-04	4885.	3.51E+10	107.9646	76626.	0.00
24.0000	-0.00756	-15176.	-2693.	1.47E-04	4961.	3.51E+10	98.8271	78408.	0.00
24.5000	-0.00669	-29699.	-2128.	1.43E-04	5050.	3.51E+10	89.3683	80190.	0.00
25.0000	-0.00584	-41000.	-1621.	1.37E-04	5120.	3.51E+10	79.8053	81972.	0.00
25.5000	-0.00504	-49420.	-1170.	1.30E-04	5172.	3.51E+10	70.3272	83754.	0.00
26.0000	-0.00429	-55301.	-775.9717	1.21E-04	5208.	3.51E+10	61.0946	85536.	0.00
26.5000	-0.00359	-58972.	-435.9671	1.11E-04	5230.	3.51E+10	52.2403	87318.	0.00
27.0000	-0.00295	-60754.	-147.6340	1.01E-04	5241.	3.51E+10	43.8708	89100.	0.00
27.5000	-0.00238	-60945.	92.1814	9.03E-05	5242.	3.51E+10	36.0677	90882.	0.00
28.0000	-0.00187	-59827.	287.0529	8.00E-05	5236.	3.51E+10	28.8895	92664.	0.00
28.5000	-0.00142	-57660.	440.8431	6.99E-05	5222.	3.51E+10	22.3739	94446.	0.00
29.0000	-0.00103	-54677.	557.5844	6.03E-05	5204.	3.51E+10	16.5399	96228.	0.00

29.5000	-6.97E-04	-51089.	641.3746	5.13E-05	5182.	3.51E+10	11.3902	98010.	0.00
30.0000	-4.16E-04	-47082.	696.2858	4.29E-05	5157.	3.51E+10	6.9135	99792.	0.00
30.5000	-1.82E-04	-42819.	726.2878	3.52E-05	5131.	3.51E+10	3.0871	101574.	0.00
31.0000	7.05E-06	-38437.	735.1849	2.83E-05	5104.	3.51E+10	-0.1214	103356.	0.00
31.5000	1.57E-04	-34053.	726.5656	2.21E-05	5077.	3.51E+10	-2.7517	105138.	0.00
32.0000	2.72E-04	-29762.	703.7646	1.66E-05	5051.	3.51E+10	-4.8487	106920.	0.00
32.5000	3.57E-04	-25641.	669.8357	1.19E-05	5025.	3.51E+10	-6.4610	108702.	0.00
33.0000	4.15E-04	-21748.	627.5351	7.85E-06	5001.	3.51E+10	-7.6392	110484.	0.00
33.5000	4.51E-04	-18126.	579.3132	4.44E-06	4979.	3.51E+10	-8.4348	112266.	0.00
34.0000	4.68E-04	-14805.	527.3142	1.62E-06	4959.	3.51E+10	-8.8982	114048.	0.00
34.5000	4.70E-04	-11802.	473.3828	-6.49E-07	4940.	3.51E+10	-9.0789	115830.	0.00
35.0000	4.60E-04	-9123.	419.0754	-2.44E-06	4924.	3.51E+10	-9.0236	117612.	0.00
35.5000	4.41E-04	-6768.	365.6764	-3.80E-06	4909.	3.51E+10	-8.7761	119394.	0.00
36.0000	4.15E-04	-4728.	314.2168	-4.78E-06	4897.	3.51E+10	-8.3770	121176.	0.00
36.5000	3.84E-04	-2988.	265.4967	-5.44E-06	4886.	3.51E+10	-7.8630	122958.	0.00
37.0000	3.50E-04	-1531.	220.1073	-5.82E-06	4877.	3.51E+10	-7.2668	124740.	0.00
37.5000	3.14E-04	-335.0083	178.4555	-5.98E-06	4870.	3.51E+10	-6.6172	126522.	0.00
38.0000	2.78E-04	622.6073	140.7870	-5.96E-06	4871.	3.51E+10	-5.9390	128304.	0.00
38.5000	2.42E-04	1366.	107.2105	-5.79E-06	4876.	3.51E+10	-5.2532	130086.	0.00
39.0000	2.08E-04	1921.	77.7193	-5.51E-06	4879.	3.51E+10	-4.5772	131868.	0.00
39.5000	1.76E-04	2310.	52.2133	-5.15E-06	4882.	3.51E+10	-3.9248	133650.	0.00
40.0000	1.47E-04	2557.	30.5182	-4.73E-06	4883.	3.51E+10	-3.3069	135432.	0.00
40.5000	1.19E-04	2686.	12.4036	-4.28E-06	4884.	3.51E+10	-2.7313	137214.	0.00
41.0000	9.51E-05	2715.	-2.4007	-3.82E-06	4884.	3.51E+10	-2.2035	138996.	0.00
41.5000	7.36E-05	2664.	-14.1906	-3.36E-06	4884.	3.51E+10	-1.7265	140778.	0.00
42.0000	5.48E-05	2551.	-23.2750	-2.92E-06	4883.	3.51E+10	-1.3017	142560.	0.00
42.5000	3.86E-05	2391.	-29.9657	-2.49E-06	4882.	3.51E+10	-0.9286	144342.	0.00
43.0000	2.49E-05	2197.	-34.5685	-2.10E-06	4881.	3.51E+10	-0.6057	146124.	0.00
43.5000	1.34E-05	1980.	-37.3757	-1.74E-06	4880.	3.51E+10	-0.3301	147906.	0.00
44.0000	3.94E-06	1752.	-38.6611	-1.42E-06	4878.	3.51E+10	-0.09837	149688.	0.00
44.5000	-3.71E-06	1519.	-38.6754	-1.15E-06	4877.	3.51E+10	0.09360	151470.	0.00
45.0000	-9.80E-06	1290.	-37.6436	-9.05E-07	4875.	3.51E+10	0.2503	153252.	0.00
45.5000	-1.46E-05	1069.	-35.7632	-7.04E-07	4874.	3.51E+10	0.3765	155034.	0.00
46.0000	-1.82E-05	862.0504	-33.2032	-5.39E-07	4873.	3.51E+10	0.4768	156816.	0.00
46.5000	-2.10E-05	671.8769	-30.1049	-4.07E-07	4872.	3.51E+10	0.5560	158598.	0.00
47.0000	-2.31E-05	501.6038	-26.5820	-3.07E-07	4871.	3.51E+10	0.6183	160380.	0.00
47.5000	-2.47E-05	353.5057	-22.7227	-2.34E-07	4870.	3.51E+10	0.6681	162162.	0.00
48.0000	-2.59E-05	229.3980	-18.5920	-1.84E-07	4869.	3.51E+10	0.7088	163944.	0.00
48.5000	-2.69E-05	130.7693	-14.2340	-1.53E-07	4868.	3.51E+10	0.7438	165726.	0.00
49.0000	-2.78E-05	58.8959	-9.6756	-1.37E-07	4868.	3.51E+10	0.7757	167508.	0.00
49.5000	-2.86E-05	14.9360	-4.9297	-1.31E-07	4868.	3.51E+10	0.8063	169290.	0.00
50.0000	-2.94E-05	0.00	0.00	-1.30E-07	4868.	3.51E+10	0.8370	85536.	0.00

* This analysis computed pile response using nonlinear moment-curvature rela-

tionships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.72000000 inches
Computed slope at pile head      =    -0.00595060 radians
Maximum bending moment           =       1365571. inch-lbs
Maximum shear force              =         14936. lbs
Depth of maximum bending moment  =    10.00000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              7
Number of zero deflection points =              3
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

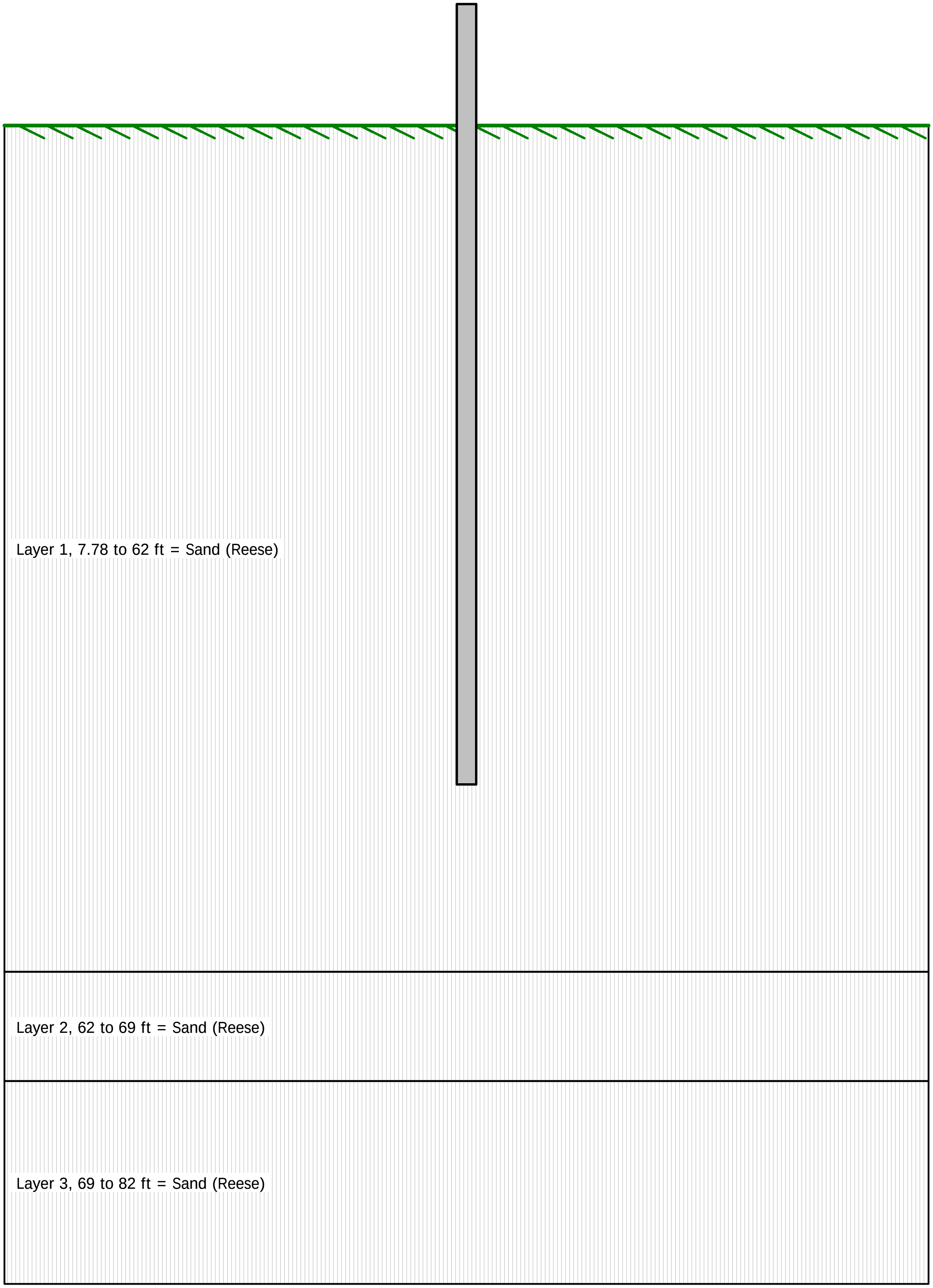
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.7200	M, in-lb	0.00	166100.	0.7200	-0.00595	14936.	1365571.

Maximum pile-head deflection = 0.7200000000 inches
Maximum pile-head rotation = -0.0059506049 radians = -0.340945 deg.

The analysis ended normally.

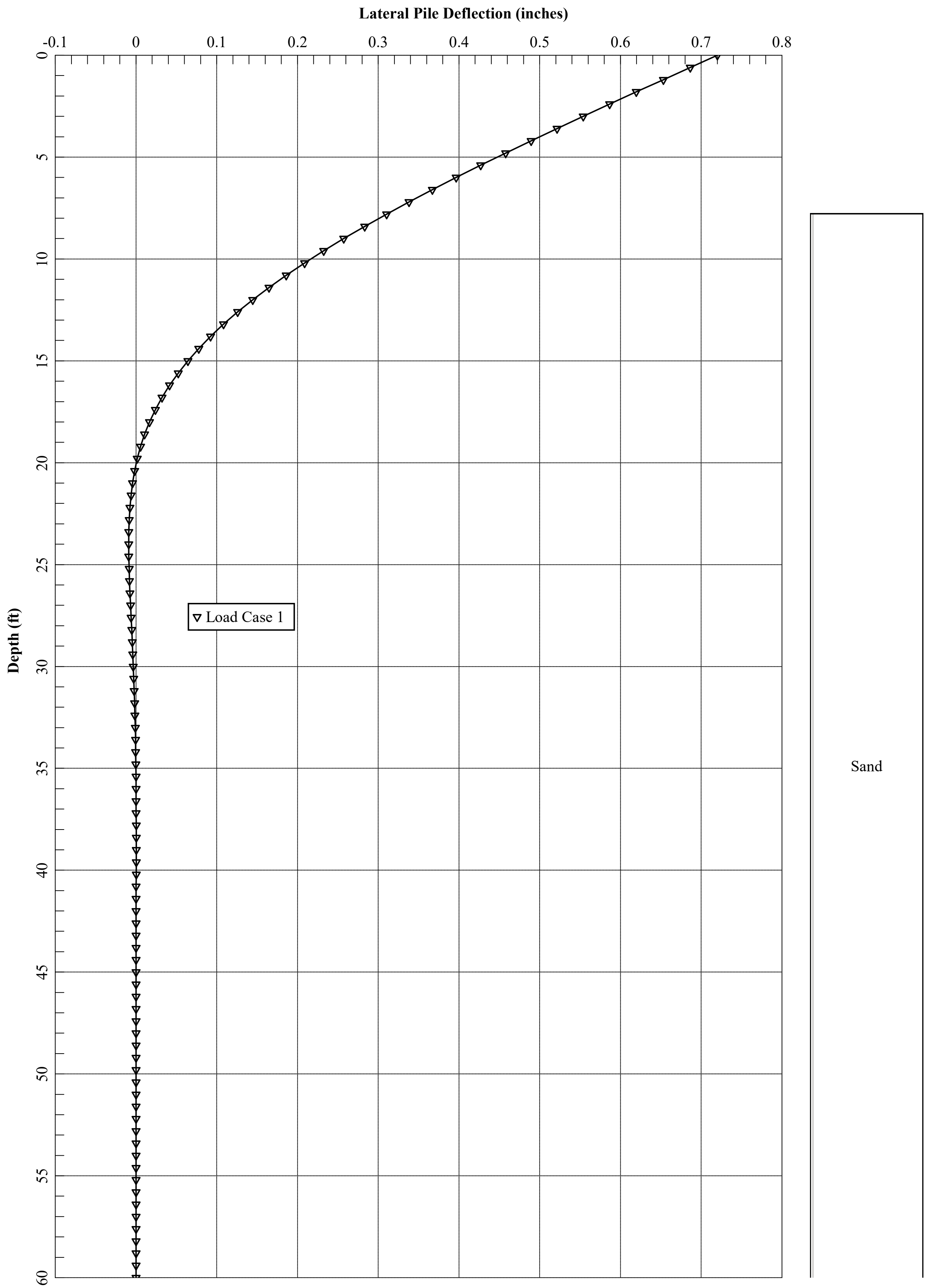
Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



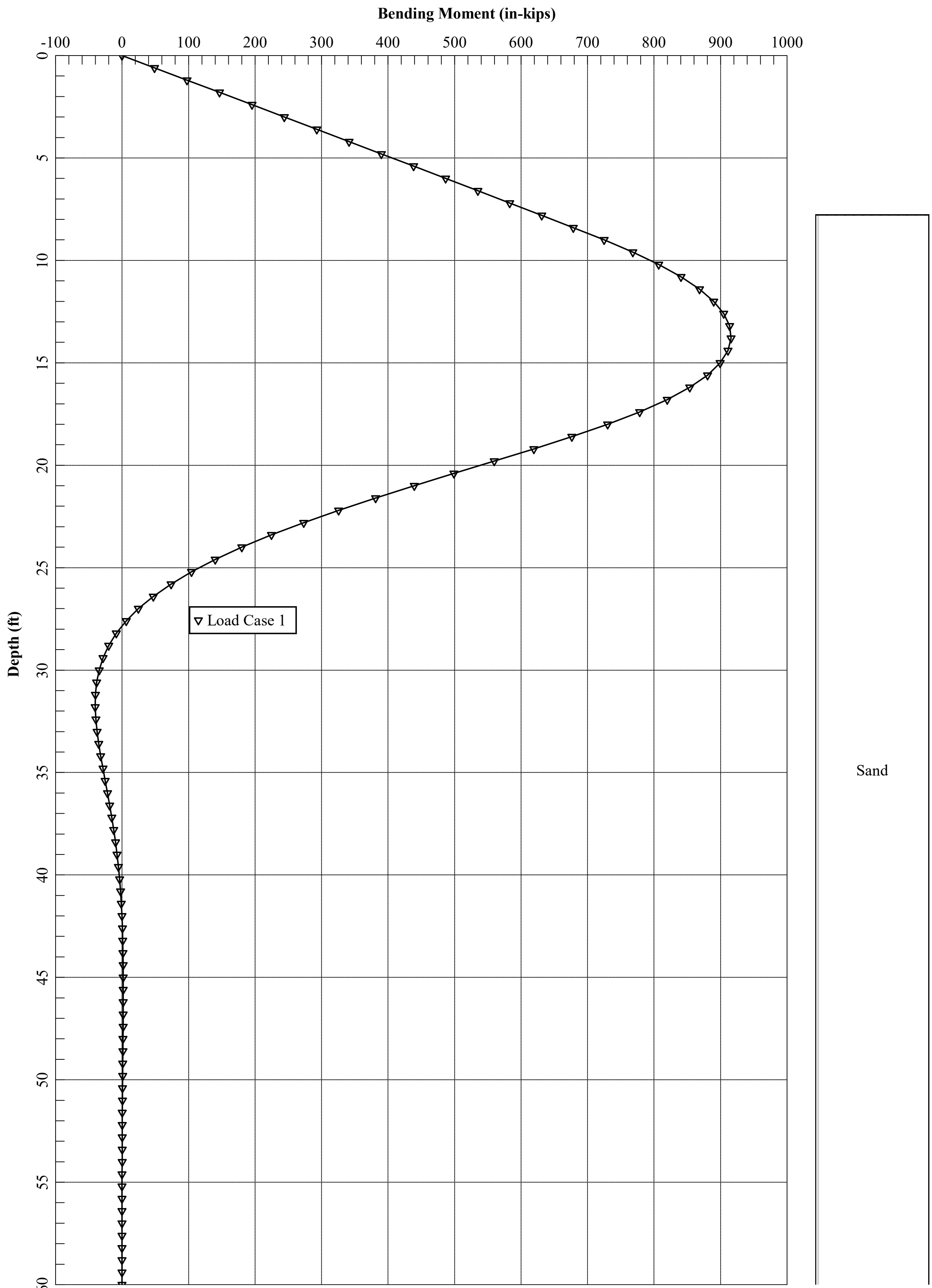
Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



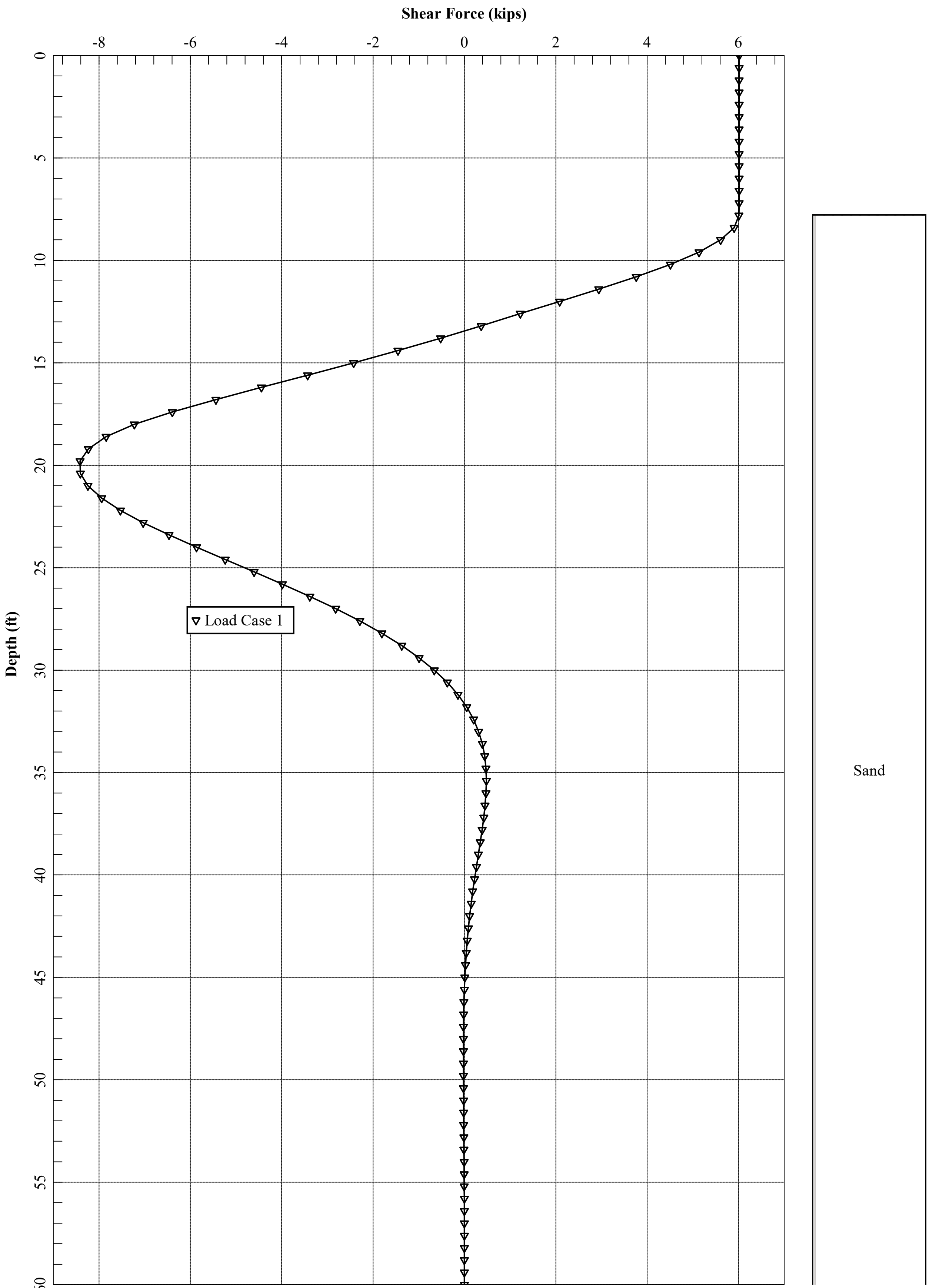
Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



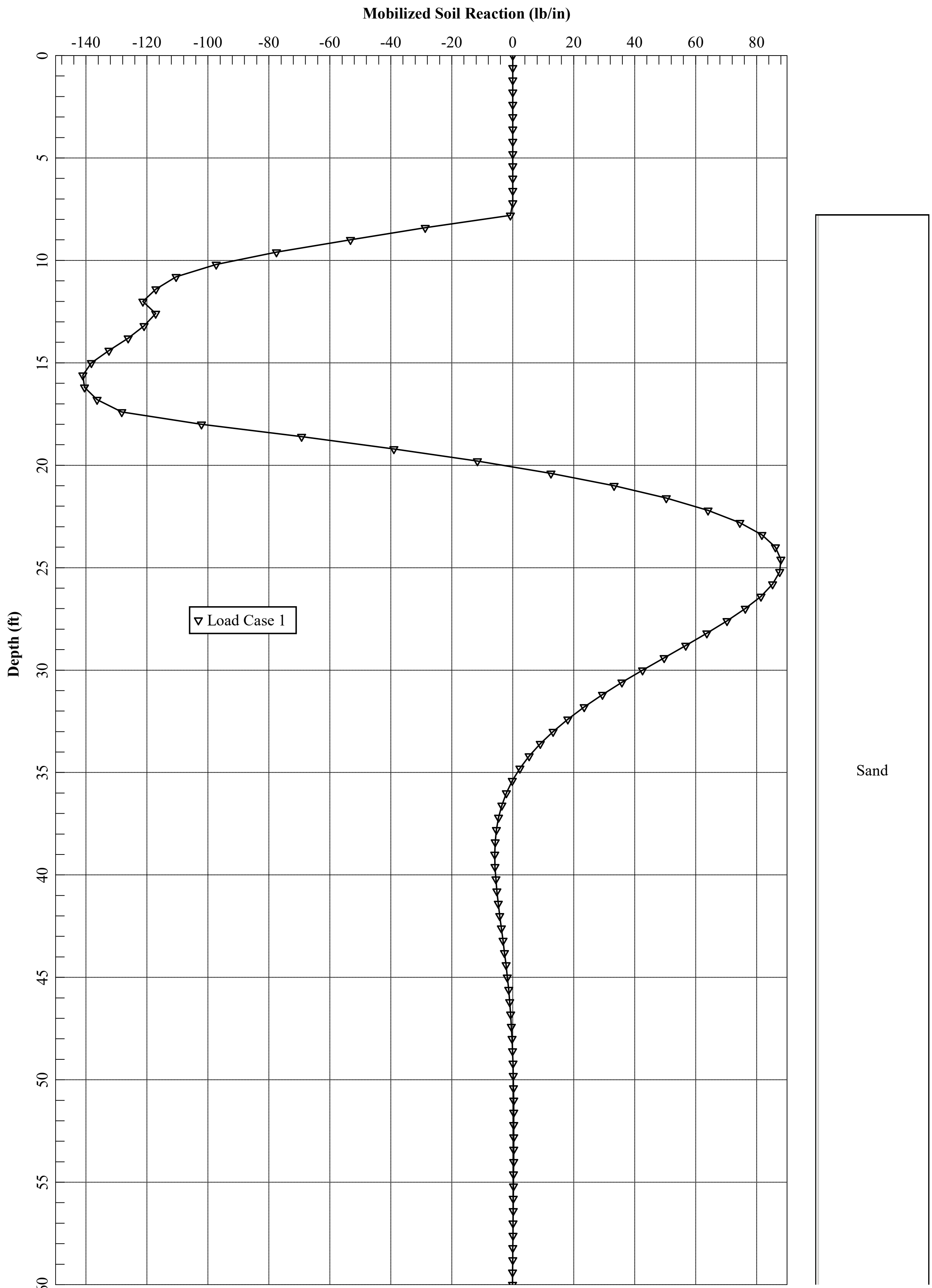
Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches



```
================================================================================

                  LPile for Windows(Beta), Version 2018-10.009

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                                     Files Used for Analysis
       --------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name of input data file:
2a. Pier HP Pile Scoured.lp10

Name of output report file:
2a. Pier HP Pile Scoured.lp10

Name of plot output file:
2a. Pier HP Pile Scoured.lp10



Name of runtime message file:
2a. Pier HP Pile Scoured.lp10



--------------------------------------------------------------------------------
```

Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches

```
                        Date and Time of Analysis
--------------------------------------------------------------------------------

              Date:  March 27, 2020            Time:  10:19:06



--------------------------------------------------------------------------------
                              Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
```

```
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                            =            1
Total length of pile                                       =       60.000 ft
Depth of ground surface below top of pile                  =       7.7800 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000            14.9000
  2           60.000            14.9000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                       =    60.000000 ft
   Pile width                                              =    14.900000 in
   Shear capacity of section                               =       0.0000 lbs
```

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =        0.000 degrees
                                                       =        0.000 radians

Pile Batter Angle                                      =        0.000 degrees
                                                       =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =     7.780000 ft
   Distance from top of pile to bottom of layer        =    62.000000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =    55.000000 pci
   Subgrade k at bottom of layer                       =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    62.000000 ft
   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
```

```
Distance from top of pile to bottom of layer        =    82.000000 ft
Effective unit weight at top of layer               =    72.600000 pcf
Effective unit weight at bottom of layer            =    72.600000 pcf
Friction angle at top of layer                      =    38.000000 deg.
Friction angle at bottom of layer                   =    38.000000 deg.
Subgrade k at top of layer                          =   120.000000 pci
Subgrade k at bottom of layer                       =   120.000000 pci
```

(Depth of the lowest soil layer extends 22.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand	7.7800	57.6000	32.0000	55.0000
	(Reese, et al.)	62.0000	57.6000	32.0000	55.0000
2	Sand	62.0000	67.6000	35.0000	86.0000
	(Reese, et al.)	69.0000	67.6000	35.0000	86.0000
3	Sand	69.0000	72.6000	38.0000	120.0000
	(Reese, et al.)	82.0000	72.6000	38.0000	120.0000

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	8.700	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

```
Static loading criteria were used when computing p-y curves for all analyses.



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load        Condition               Condition            Axial Thrust      Compute Top y
 No.    Type            1                       2                 Force, lbs     vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------   ---------------
   1     4     y =     0.720000 in    M =       0.0000 in-lbs           166100.          N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.



--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel H Strong Axis:
---------------------------------------------

Length of Section                                       =    60.000000 ft
Flange Width                                            =    14.900000 in
Section Depth                                           =    14.200000 in
Flange Thickness                                        =     0.805000 in
Web Thickness                                           =     0.805000 in
Yield Stress of Pipe                                    =    50.000000 ksi
```

```
Elastic Modulus                                          =       29000. ksi
Cross-sectional Area                                     =    34.123950 sq. in.
Moment of Inertia                                        =        1211. in^4
Elastic Bending Stiffness                                =    35125694. kip-in^2
Plastic Modulus, Z                                       =   192.566083in^3
Plastic Moment Capacity = Fy Z                           =        9628.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                   =     1706.197 kips
Nominal Axial Tensile Capacity                           =    -1706.197 kips



Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1             166.100

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =    166.100 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000464	162.7359835	35100995.	43.3033008	5.8126011	
0.00000927	325.4719670	35100995.	25.2016504	6.7576530	
0.00001391	488.2079505	35100995.	19.1677669	7.7027051	
0.00001854	650.9439340	35100995.	16.1508252	8.6477571	
0.00002318	813.6799175	35100995.	14.3406602	9.5928091	
0.00002782	976.4159011	35100995.	13.1338835	10.5378612	
0.00003245	1139.	35100995.	12.2719001	11.4829132	
0.00003709	1302.	35100995.	11.6254126	12.4279652	
0.00004173	1465.	35100995.	11.1225890	13.3730172	
0.00004636	1627.	35100995.	10.7203301	14.3180693	
0.00005100	1790.	35100995.	10.3912092	15.2631213	
0.00005563	1953.	35100995.	10.1169417	16.2081733	
0.00006027	2116.	35100995.	9.8848693	17.1532253	

0.00006491	2278.	35100995.	9.6859501	18.0982774	
0.00006954	2441.	35100995.	9.5135534	19.0433294	
0.00007418	2604.	35100995.	9.3627063	19.9883814	
0.00007882	2767.	35100995.	9.2296059	20.9334334	
0.00008345	2929.	35100995.	9.1112945	21.8784855	
0.00008809	3092.	35100995.	9.0054369	22.8235375	
0.00009272	3255.	35100995.	8.9101650	23.7685895	
0.00009736	3417.	35100995.	8.8239667	24.7136415	
0.0001020	3580.	35100995.	8.7456046	25.6586935	
0.0001066	3743.	35100995.	8.6740566	26.6037456	
0.0001113	3906.	35100995.	8.6084709	27.5487976	
0.0001159	4068.	35100995.	8.5481320	28.4938496	
0.0001205	4231.	35100995.	8.4924346	29.4389016	
0.0001252	4394.	35100995.	8.4408630	30.3839537	
0.0001298	4557.	35100995.	8.3929750	31.3290057	
0.0001345	4719.	35100995.	8.3483897	32.2740577	
0.0001391	4882.	35100995.	8.3067767	33.2191097	
0.0001437	5045.	35100995.	8.2678484	34.1641618	
0.0001484	5208.	35100995.	8.2313532	35.1092138	
0.0001530	5370.	35100995.	8.1970697	36.0542658	
0.0001576	5533.	35100995.	8.1648030	36.9993178	
0.0001623	5696.	35100995.	8.1343800	37.9443698	
0.0001669	5858.	35100995.	8.1056472	38.8894219	
0.0001715	6021.	35100995.	8.0784676	39.8344739	
0.0001762	6184.	35100995.	8.0527184	40.7795259	
0.0001808	6347.	35100995.	8.0282898	41.7245779	
0.0001901	6672.	35100995.	7.9830073	43.6146820	
0.0001994	6998.	35100995.	7.9419372	45.5047860	
0.0002086	7323.	35100995.	7.9045178	47.3948901	
0.0002179	7649.	35100995.	7.8702830	49.2849941	
0.0002272	7950.	34995721.	7.8540420	50.0000000	Y
0.0002364	8175.	34574208.	7.8870509	50.0000000	Y
0.0002457	8301.	33782029.	7.9793307	50.0000000	Y
0.0002550	8396.	32927515.	8.0837199	50.0000000	Y
0.0002643	8485.	32106540.	8.1851565	50.0000000	Y
0.0002735	8567.	31318147.	8.2836741	50.0000000	Y
0.0002828	8643.	30561645.	8.3792485	50.0000000	Y
0.0002921	8714.	29835633.	8.4719742	50.0000000	Y
0.0003014	8781.	29138830.	8.5619263	50.0000000	Y
0.0003106	8844.	28470055.	8.6491623	50.0000000	Y
0.0003199	8902.	27827245.	8.7330580	50.0000000	Y
0.0003292	8953.	27198453.	8.8069420	50.0000000	Y
0.0003384	9000.	26593579.	8.8768847	50.0000000	Y
0.0003477	9042.	26003928.	8.9378853	50.0000000	Y
0.0003570	9080.	25435938.	8.9946017	50.0000000	Y
0.0003663	9114.	24882952.	9.0424503	50.0000000	Y
0.0003755	9144.	24348373.	9.0853846	50.0000000	Y

0.0003848	9169.	23827650.	9.1190575	50.0000000	Y
0.0003941	9190.	23321194.	9.1441461	50.0000000	Y
0.0004034	9208.	22827723.	9.1602639	50.0000000	Y
0.0004126	9219.	22343397.	9.1633431	50.0000000	Y
0.0004219	9230.	21876613.	9.1633967	50.0000000	Y
0.0004312	9239.	21428326.	9.1633021	50.0000000	Y
0.0004404	9248.	20997294.	9.1633647	50.0000000	Y
0.0004497	9257.	20583405.	9.1633565	50.0000000	Y
0.0004590	9264.	20184379.	9.1633464	50.0000000	Y
0.0004683	9272.	19800860.	9.1634274	50.0000000	Y
0.0004775	9279.	19430719.	9.1633414	50.0000000	Y
0.0004868	9286.	19074485.	9.1634326	50.0000000	Y
0.0004961	9292.	18730197.	9.1633497	50.0000000	Y
0.0005053	9298.	18398538.	9.1632801	50.0000000	Y
0.0005146	9303.	18077537.	9.1633714	50.0000000	Y
0.0005239	9308.	17767812.	9.1632940	50.0000000	Y
0.0005332	9313.	17468162.	9.1634069	50.0000000	Y
0.0005424	9318.	17178234.	9.1633315	50.0000000	Y
0.0005517	9323.	16898017.	9.1633310	50.0000000	Y
0.0005888	9339.	15860447.	9.1633798	50.0000000	Y
0.0006259	9352.	14941699.	9.1633315	50.0000000	Y
0.0006630	9363.	14122530.	9.1633103	50.0000000	Y
0.0007001	9372.	13387675.	9.1633152	50.0000000	Y
0.0007372	9380.	12724886.	9.1633464	50.0000000	Y
0.0007742	9387.	12124211.	9.1634052	50.0000000	Y
0.0008113	9393.	11577470.	9.1634937	50.0000000	Y
0.0008484	9398.	11077283.	9.1632973	50.0000000	Y
0.0008855	9403.	10618456.	9.1634223	50.0000000	Y
0.0009226	9407.	10195985.	9.1632445	50.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	166.1000000000	9407.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	7.7800	0.00	N.A.	No	0.00	3040691.
2	62.0000	54.2200	No	No	3040691.	0.00
3	69.0000	61.2200	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)
Displacement of pile head = 0.720000 inches
Moment at pile head = 0.0 in-lbs
Axial load at pile head = 166100.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7200	0.00	6014.	-0.00466	4868.	3.51E+10	0.00	0.00	0.00

Pier HP Pile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.72 inches

0.6000	0.6865	48870.	6014.	-0.00465	5168.	3.51E+10	0.00	0.00	0.00
1.2000	0.6530	97729.	6014.	-0.00464	5469.	3.51E+10	0.00	0.00	0.00
1.8000	0.6197	146563.	6014.	-0.00461	5769.	3.51E+10	0.00	0.00	0.00
2.4000	0.5866	195362.	6014.	-0.00458	6069.	3.51E+10	0.00	0.00	0.00
3.0000	0.5538	244112.	6014.	-0.00453	6369.	3.51E+10	0.00	0.00	0.00
3.6000	0.5214	292803.	6014.	-0.00448	6669.	3.51E+10	0.00	0.00	0.00
4.2000	0.4893	341422.	6014.	-0.00441	6968.	3.51E+10	0.00	0.00	0.00
4.8000	0.4578	389957.	6014.	-0.00434	7266.	3.51E+10	0.00	0.00	0.00
5.4000	0.4269	438396.	6014.	-0.00425	7564.	3.51E+10	0.00	0.00	0.00
6.0000	0.3966	486728.	6014.	-0.00416	7861.	3.51E+10	0.00	0.00	0.00
6.6000	0.3671	534941.	6014.	-0.00405	8158.	3.51E+10	0.00	0.00	0.00
7.2000	0.3383	583022.	6014.	-0.00394	8454.	3.51E+10	0.00	0.00	0.00
7.8000	0.3104	630960.	6011.	-0.00381	8748.	3.51E+10	-0.8066	18.7120	0.00
8.4000	0.2834	678702.	5905.	-0.00368	9042.	3.51E+10	-28.7483	730.4181	0.00
9.0000	0.2574	724787.	5610.	-0.00353	9326.	3.51E+10	-53.2049	1488.	0.00
9.6000	0.2325	767936.	5139.	-0.00338	9591.	3.51E+10	-77.5482	2402.	0.00
10.2000	0.2087	806876.	4510.	-0.00322	9830.	3.51E+10	-97.2711	3356.	0.00
10.8000	0.1861	840576.	3762.	-0.00305	10038.	3.51E+10	-110.4756	4273.	0.00
11.4000	0.1648	868343.	2943.	-0.00288	10209.	3.51E+10	-117.0667	5115.	0.00
12.0000	0.1447	889828.	2084.	-0.00269	10341.	3.51E+10	-121.3370	6036.	0.00
12.6000	0.1260	904804.	1226.	-0.00251	10433.	3.51E+10	-117.1253	6694.	0.00
13.2000	0.1086	913487.	368.9470	-0.00232	10486.	3.51E+10	-120.9315	8020.	0.00
13.8000	0.09251	915677.	-520.6745	-0.00214	10500.	3.51E+10	-126.1856	9821.	0.00
14.4000	0.07780	911100.	-1452.	-0.00195	10472.	3.51E+10	-132.4737	12260.	0.00
15.0000	0.06444	899433.	-2426.	-0.00176	10400.	3.51E+10	-138.2384	15447.	0.00
15.6000	0.05240	880379.	-3432.	-0.00158	10283.	3.51E+10	-141.0188	19376.	0.00
16.2000	0.04167	853798.	-4445.	-0.00140	10119.	3.51E+10	-140.4947	24277.	0.00
16.8000	0.03219	819725.	-5442.	-0.00123	9909.	3.51E+10	-136.3606	30497.	0.00
17.4000	0.02393	778381.	-6395.	-0.00107	9655.	3.51E+10	-128.2906	38600.	0.00
18.0000	0.01682	730196.	-7224.	-9.13E-04	9359.	3.51E+10	-102.0858	43709.	0.00
18.6000	0.01078	676540.	-7841.	-7.69E-04	9029.	3.51E+10	-69.2908	46275.	0.00
19.2000	0.00575	619126.	-8231.	-6.36E-04	8676.	3.51E+10	-38.9718	48841.	0.00
19.8000	0.00162	559540.	-8413.	-5.15E-04	8309.	3.51E+10	-11.5917	51407.	0.00
20.4000	-0.00167	499215.	-8409.	-4.06E-04	7938.	3.51E+10	12.5316	53973.	0.00
21.0000	-0.00423	439418.	-8245.	-3.10E-04	7570.	3.51E+10	33.2140	56539.	0.00
21.6000	-0.00614	381234.	-7944.	-2.26E-04	7212.	3.51E+10	50.3923	59105.	0.00
22.2000	-0.00748	325570.	-7531.	-1.54E-04	6870.	3.51E+10	64.1087	61671.	0.00
22.8000	-0.00835	273149.	-7032.	-9.21E-05	6548.	3.51E+10	74.4945	64238.	0.00
23.4000	-0.00881	224523.	-6470.	-4.11E-05	6249.	3.51E+10	81.7541	66804.	0.00
24.0000	-0.00894	180080.	-5866.	4.00E-07	5975.	3.51E+10	86.1479	69370.	0.00
24.6000	-0.00881	140058.	-5239.	3.32E-05	5729.	3.51E+10	87.9773	71936.	0.00
25.2000	-0.00846	104563.	-4607.	5.83E-05	5511.	3.51E+10	87.5695	74502.	0.00
25.8000	-0.00797	73582.	-3985.	7.66E-05	5320.	3.51E+10	85.2644	77068.	0.00
26.4000	-0.00736	47003.	-3385.	8.90E-05	5157.	3.51E+10	81.4030	79634.	0.00
27.0000	-0.00668	24633.	-2817.	9.63E-05	5019.	3.51E+10	76.3173	82200.	0.00
27.6000	-0.00597	6212.	-2289.	9.95E-05	4906.	3.51E+10	70.3220	84766.	0.00
28.2000	-0.00525	-8564.	-1806.	9.92E-05	4920.	3.51E+10	63.7082	87332.	0.00

28.8000	-0.00454	-20036.	-1373.	9.63E-05	4991.	3.51E+10	56.7385	89898.	0.00
29.4000	-0.00387	-28561.	-989.7135	9.13E-05	5043.	3.51E+10	49.6441	92464.	0.00
30.0000	-0.00323	-34506.	-657.5530	8.48E-05	5080.	3.51E+10	42.6227	95030.	0.00
30.6000	-0.00264	-38233.	-375.0923	7.74E-05	5103.	3.51E+10	35.8386	97597.	0.00
31.2000	-0.00211	-40093.	-140.1517	6.94E-05	5114.	3.51E+10	29.4227	100163.	0.00
31.8000	-0.00165	-40417.	50.2786	6.11E-05	5116.	3.51E+10	23.4746	102729.	0.00
32.4000	-0.00124	-39515.	199.8199	5.29E-05	5111.	3.51E+10	18.0646	105295.	0.00
33.0000	-8.84E-04	-37666.	312.5045	4.50E-05	5099.	3.51E+10	13.2367	107861.	0.00
33.6000	-5.88E-04	-35122.	392.5967	3.75E-05	5084.	3.51E+10	9.0112	110427.	0.00
34.2000	-3.43E-04	-32102.	444.4364	3.06E-05	5065.	3.51E+10	5.3887	112993.	0.00
34.8000	-1.47E-04	-28796.	472.3073	2.44E-05	5045.	3.51E+10	2.3532	115559.	0.00
35.4000	7.61E-06	-25360.	480.3291	1.88E-05	5024.	3.51E+10	-0.1249	118125.	0.00
36.0000	1.24E-04	-21924.	472.3732	1.40E-05	5002.	3.51E+10	-2.0851	120691.	0.00
36.6000	2.09E-04	-18591.	451.9997	9.82E-06	4982.	3.51E+10	-3.5742	123257.	0.00
37.2000	2.66E-04	-15438.	422.4151	6.33E-06	4963.	3.51E+10	-4.6437	125823.	0.00
37.8000	3.00E-04	-12523.	386.4478	3.46E-06	4945.	3.51E+10	-5.3472	128390.	0.00
38.4000	3.16E-04	-9882.	346.5388	1.16E-06	4928.	3.51E+10	-5.7386	130956.	0.00
39.0000	3.17E-04	-7536.	304.7457	-6.27E-07	4914.	3.51E+10	-5.8706	133522.	0.00
39.6000	3.06E-04	-5492.	262.7572	-1.96E-06	4901.	3.51E+10	-5.7929	136088.	0.00
40.2000	2.88E-04	-3747.	221.9161	-2.91E-06	4891.	3.51E+10	-5.5518	138654.	0.00
40.8000	2.65E-04	-2289.	183.2482	-3.53E-06	4882.	3.51E+10	-5.1893	141220.	0.00
41.4000	2.37E-04	-1100.	147.4947	-3.88E-06	4874.	3.51E+10	-4.7423	143786.	0.00
42.0000	2.09E-04	-156.2996	115.1481	-4.01E-06	4869.	3.51E+10	-4.2429	146352.	0.00
42.6000	1.80E-04	567.6007	86.4877	-3.96E-06	4871.	3.51E+10	-3.7183	148918.	0.00
43.2000	1.52E-04	1099.	61.6154	-3.79E-06	4874.	3.51E+10	-3.1907	151484.	0.00
43.8000	1.25E-04	1464.	40.4891	-3.53E-06	4877.	3.51E+10	-2.6777	154050.	0.00
44.4000	1.01E-04	1690.	22.9547	-3.21E-06	4878.	3.51E+10	-2.1929	156616.	0.00
45.0000	7.90E-05	1802.	8.7747	-2.85E-06	4879.	3.51E+10	-1.7460	159182.	0.00
45.6000	5.98E-05	1823.	-2.3464	-2.48E-06	4879.	3.51E+10	-1.3432	161749.	0.00
46.2000	4.33E-05	1774.	-10.7397	-2.11E-06	4878.	3.51E+10	-0.9883	164315.	0.00
46.8000	2.94E-05	1674.	-16.7536	-1.75E-06	4878.	3.51E+10	-0.6823	166881.	0.00
47.4000	1.80E-05	1537.	-20.7383	-1.43E-06	4877.	3.51E+10	-0.4246	169447.	0.00
48.0000	8.92E-06	1378.	-23.0336	-1.13E-06	4876.	3.51E+10	-0.2130	172013.	0.00
48.6000	1.83E-06	1208.	-23.9598	-8.61E-07	4875.	3.51E+10	-0.04428	174579.	0.00
49.2000	-3.48E-06	1035.	-23.8111	-6.31E-07	4874.	3.51E+10	0.08559	177145.	0.00
49.8000	-7.25E-06	866.8730	-22.8511	-4.35E-07	4873.	3.51E+10	0.1811	179711.	0.00
50.4000	-9.75E-06	707.4528	-21.2119	-2.74E-07	4872.	3.51E+10	0.2743	202530.	0.00
51.0000	-1.12E-05	562.0765	-19.0744	-1.44E-07	4871.	3.51E+10	0.3195	205381.	0.00
51.6000	-1.18E-05	433.1251	-16.6935	-4.18E-08	4870.	3.51E+10	0.3419	208233.	0.00
52.2000	-1.18E-05	321.7905	-14.2171	3.57E-08	4870.	3.51E+10	0.3460	211084.	0.00
52.8000	-1.13E-05	228.3135	-11.7620	9.21E-08	4869.	3.51E+10	0.3360	213935.	0.00
53.4000	-1.05E-05	152.1979	-9.4169	1.31E-07	4868.	3.51E+10	0.3154	216786.	0.00
54.0000	-9.42E-06	92.3963	-7.2470	1.56E-07	4868.	3.51E+10	0.2873	219637.	0.00
54.6000	-8.23E-06	47.4680	-5.2974	1.71E-07	4868.	3.51E+10	0.2542	222489.	0.00
55.2000	-6.96E-06	15.7065	-3.5976	1.77E-07	4868.	3.51E+10	0.2179	225340.	0.00
55.8000	-5.68E-06	-4.7605	-2.1652	1.78E-07	4868.	3.51E+10	0.1799	228191.	0.00
56.4000	-4.40E-06	-15.8981	-1.0093	1.76E-07	4868.	3.51E+10	0.1411	231042.	0.00

57.0000	-3.14E-06	-19.7149	-0.1336	1.72E-07	4868.	3.51E+10	0.1021	233893.	0.00
57.6000	-1.92E-06	-18.2341	0.4608	1.68E-07	4868.	3.51E+10	0.06301	236745.	0.00
58.2000	-7.17E-07	-13.4822	0.7735	1.65E-07	4868.	3.51E+10	0.02385	239596.	0.00
58.8000	4.63E-07	-7.4905	0.8033	1.63E-07	4868.	3.51E+10	-0.01559	242447.	0.00
59.4000	1.63E-06	-2.3048	0.5471	1.62E-07	4868.	3.51E+10	-0.05558	245298.	0.00
60.0000	2.80E-06	0.00	0.00	1.62E-07	4868.	3.51E+10	-0.09639	124075.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.72000000 inches
Computed slope at pile head      =    -0.00465654 radians
Maximum bending moment           =        915677. inch-lbs
Maximum shear force              =         -8413. lbs
Depth of maximum bending moment  =    13.80000000 feet below pile head
Depth of maximum shear force     =    19.80000000 feet below pile head
Number of iterations             =              8
Number of zero deflection points =              4
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

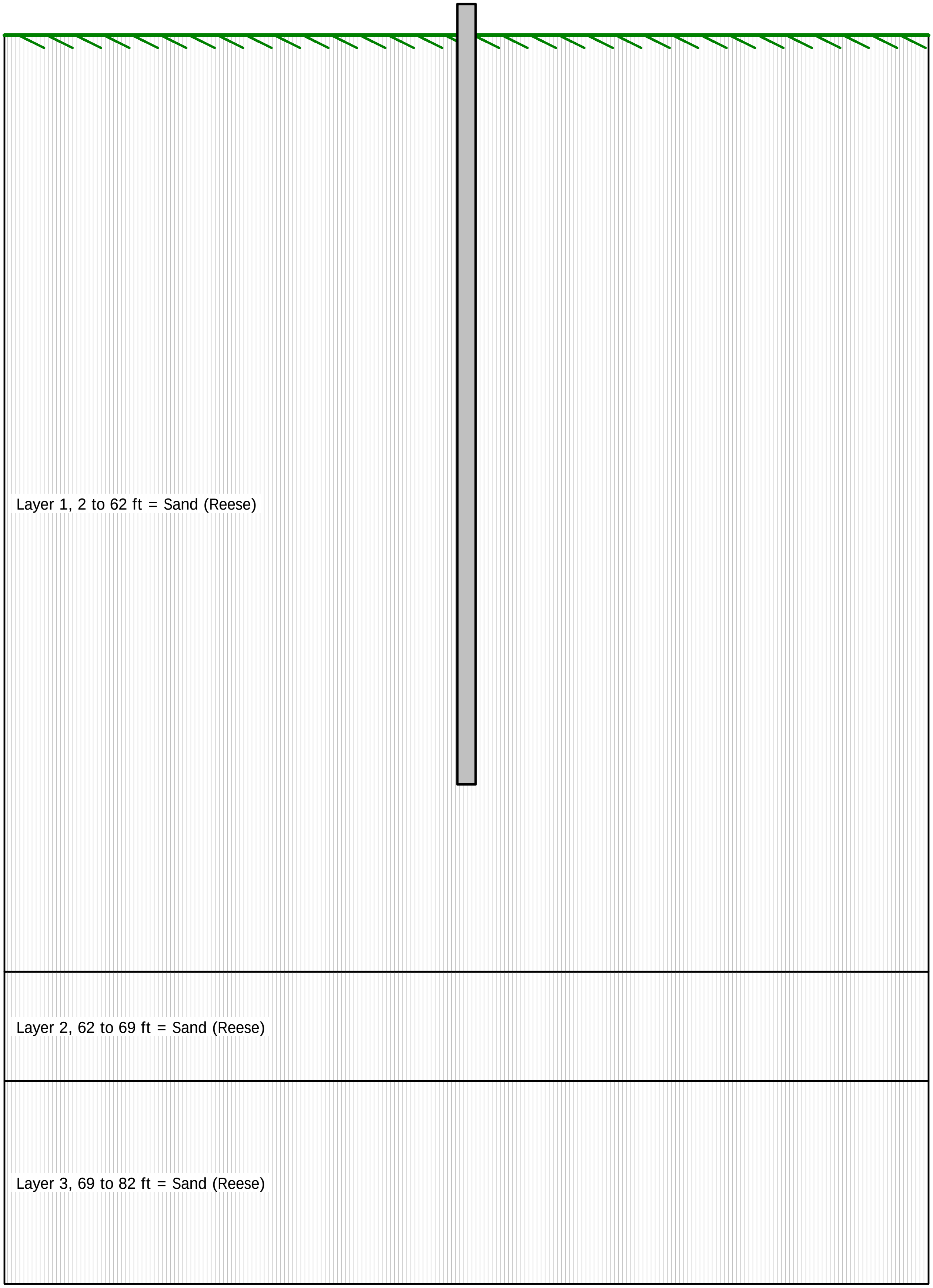
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	y, in	0.7200	M, in-lb	0.00	166100.	0.7200	-0.00466	-8413.	915677.

```
Maximum pile-head deflection = 0.7200000000 inches
Maximum pile-head rotation   = -0.0046565447 radians = -0.266800 deg.

The analysis ended normally.
```

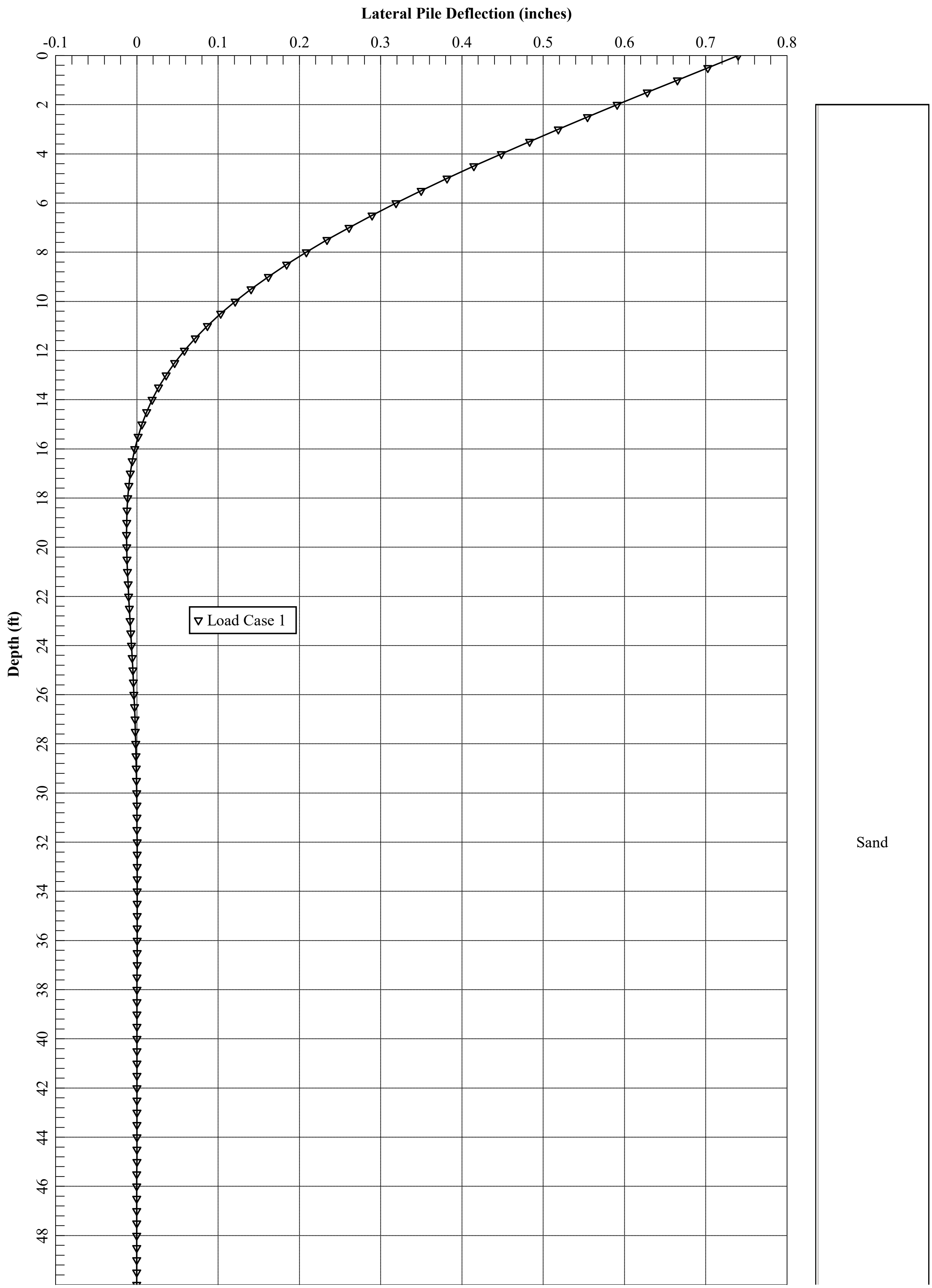
Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



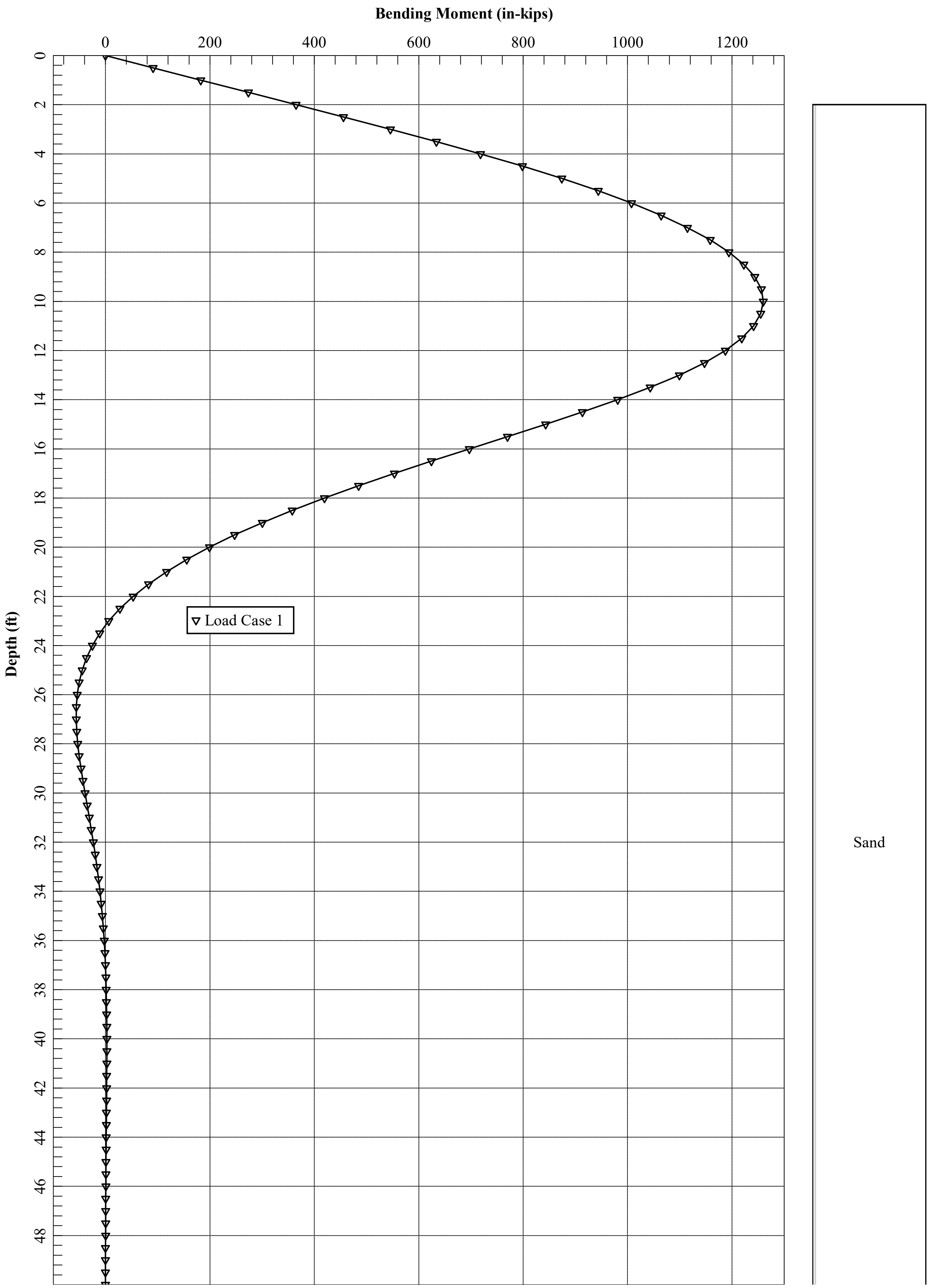
Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



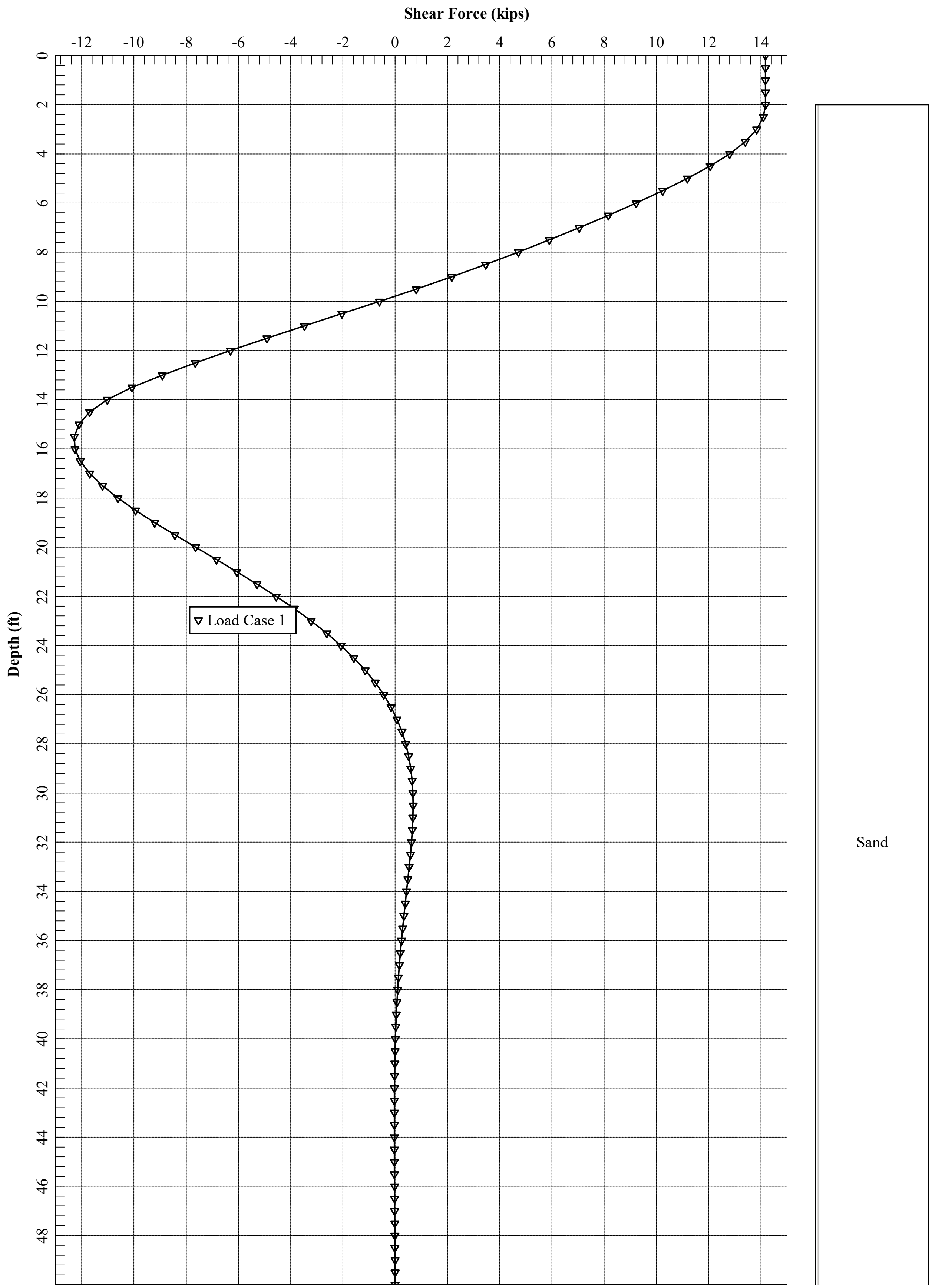
Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



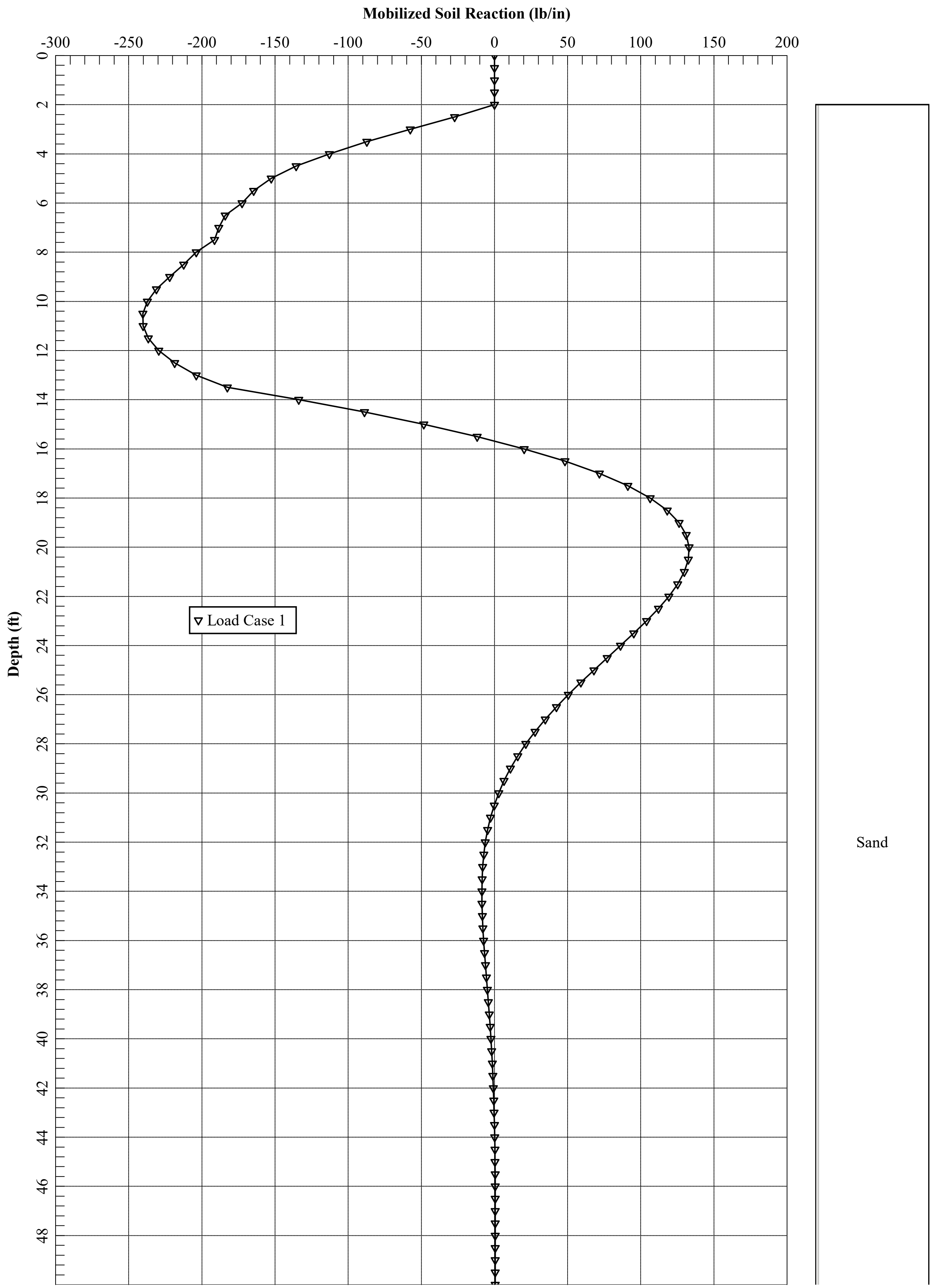
Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



```
===============================================================================

                 LPile for Windows(Beta), Version 2018-10.009

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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-------------------------------------------------------------------------------
                                     Files Used for Analysis
       -------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name of input data file:
2. Pier Micropile.lp10

Name of output report file:
2. Pier Micropile.lp10

Name of plot output file:
2. Pier Micropile.lp10

Name of runtime message file:
2. Pier Micropile.lp10


-------------------------------------------------------------------------------
```

```
                      Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  March 27, 2020             Time:  10:20:56



--------------------------------------------------------------------------------
                            Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment




--------------------------------------------------------------------------------
                    Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed               =          500
 - Deflection tolerance for convergence               =   1.0000E-05 in
 - Maximum allowable deflection                       =     100.0000 in
 - Number of pile increments                          =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
```

```
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                          =            1
Total length of pile                                     =       50.000 ft
Depth of ground surface below top of pile                =       2.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------    -------------
  1            0.000           16.0000
  2           50.000           16.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                     =    50.000000 ft
   Casing outside diameter                               =    16.000000 in
   Shear capacity of section                             =       0.0000 lbs
```

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                     =       0.000 degrees
                                                       =       0.000 radians

Pile Batter Angle                                      =       0.000 degrees
                                                       =       0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =     2.000000 ft
   Distance from top of pile to bottom of layer        =    62.000000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    32.000000 deg.
   Friction angle at bottom of layer                   =    32.000000 deg.
   Subgrade k at top of layer                          =    55.000000 pci
   Subgrade k at bottom of layer                       =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    62.000000 ft
   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
```

```
  Distance from top of pile to bottom of layer        =    82.000000 ft
  Effective unit weight at top of layer               =    72.600000 pcf
  Effective unit weight at bottom of layer            =    72.600000 pcf
  Friction angle at top of layer                      =    38.000000 deg.
  Friction angle at bottom of layer                   =    38.000000 deg.
  Subgrade k at top of layer                          =   120.000000 pci
  Subgrade k at bottom of layer                       =   120.000000 pci

 (Depth of the lowest soil layer extends 32.000 ft below the pile tip)
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand	2.0000	57.6000	32.0000	55.0000
	(Reese, et al.)	62.0000	57.6000	32.0000	55.0000
2	Sand	62.0000	67.6000	35.0000	86.0000
	(Reese, et al.)	69.0000	67.6000	35.0000	86.0000
3	Sand	69.0000	72.6000	38.0000	120.0000
	(Reese, et al.)	82.0000	72.6000	38.0000	120.0000

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	2.000	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4	y = 0.740000 in	M = 0.0000 in-lbs	166100.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	50.000000 ft
Outer Diameter of Casing	=	16.000000 in
Concrete Cover Thickness Inside Casing	=	3.000000 in
Casing Wall Thickness	=	0.500000 in
Moment of Inertia of Steel Casing	=	731.942001 in^4
Yield Stress of Casing	=	50000. psi

Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	4.000000 sq. in.
Edge-to-Edge Bar Spacing	=	-2.257000 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	-3.01
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	201.061930 sq. in.
Area of Concrete	=	172.714587 sq. in.
Cross-sectional Area of Steel Casing	=	24.347343 sq. in.
Area of All Steel (Casing and Bars)	=	28.347343 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	14.10 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	2191.404 kips
Tensile Load for Cracking of Concrete	=	-174.557 kips
Nominal Axial Tensile Capacity	=	-1457.367 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	2.257000	4.000000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.330086 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	166.100

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 166.100 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	40.5891926	32471354.	89.9685551	0.0001125	0.00009246	0.5185959	3.2584601	3.2584601	
0.00000250	81.1770662	32470826.	48.9875440	0.0001225	0.00008247	0.5629647	3.5457970	3.5457970	
0.00000375	121.7647117	32470590.	35.3286604	0.0001325	0.00007248	0.6071369	3.8332918	3.8332918	
0.00000500	162.3520148	32470403.	28.5003087	0.0001425	0.00006250	0.6511123	4.1209448	4.1209448	
0.00000625	202.9388616	32470218.	24.4041698	0.0001525	0.00005253	0.6948904	4.4087558	4.4087558	
0.00000750	243.5251377	32470018.	21.6741372	0.0001626	0.00004256	0.7384710	4.6967249	4.6967249	
0.00000875	284.1107290	32469798.	19.7247369	0.0001726	0.00003259	0.7818536	4.9848520	4.9848520	
0.00001000	324.6955214	32469552.	18.2632317	0.0001826	0.00002263	0.8250378	5.2731372	5.2731372	
0.00001125	365.2794006	32469280.	17.1269900	0.0001927	0.00001268	0.8680233	5.5615805	5.5615805	
0.00001250	405.8622525	32468980.	16.2184327	0.0002027	0.00000273	0.9108098	5.8501819	5.8501819	
0.00001375	446.4439628	32468652.	15.4754641	0.0002128	-0.00000721	0.9533969	6.1389414	6.1389414	
0.00001500	487.0234786	32468232.	14.8566817	0.0002229	-0.00001715	0.9957838	6.4278566	6.4278566	
0.00001625	527.5950678	32467389.	14.3333961	0.0002329	-0.00002708	1.0379681	6.7169130	6.7169130	
0.00001750	568.1514929	32465800.	13.8851048	0.0002430	-0.00003701	1.0799466	7.0060907	7.0060907	
0.00001875	608.6866466	32463288.	13.4967758	0.0002531	-0.00004694	1.1217164	7.2953719	7.2953719	
0.00002000	649.1957032	32459785.	13.1571399	0.0002631	-0.00005686	1.1632751	7.5847412	7.5847412	
0.00002125	689.6749410	32455291.	12.8575838	0.0002732	-0.00006678	1.2046207	7.8741861	7.8741861	
0.00002250	730.1214756	32449843.	12.5914116	0.0002833	-0.00007669	1.2457516	8.1636961	8.1636961	

0.00002375	770.5330975	32443499.	12.3533399	0.0002934	-0.00008661	1.2866663	8.4532629	8.4532629	
0.00002500	810.9080331	32436321.	12.1391437	0.0003035	-0.00009652	1.3273639	8.7428793	8.7428793	
0.00002625	851.2449286	32428378.	11.9454048	0.0003136	-0.0001064	1.3678433	9.0325395	9.0325395	
0.00002750	851.2449286	30954361.	11.5979150	0.0003189	-0.0001211	1.3891339	9.1855373	9.1855373	C
0.00002875	881.7711027	30670299.	11.4173268	0.0003282	-0.0001318	1.4261330	9.4524963	9.4524963	C
0.00003000	915.2618004	30508727.	11.2506402	0.0003375	-0.0001425	1.4628043	9.7184570	9.7184570	C
0.00003125	948.5542753	30353737.	11.0962863	0.0003468	-0.0001532	1.4991622	9.9835095	9.9835095	C
0.00003250	981.6732552	30205331.	10.9529452	0.0003560	-0.0001640	1.5352219	10.2477509	10.2477509	C
0.00003375	1015.	30062768.	10.8193505	0.0003652	-0.0001748	1.5709794	10.5111394	10.5111394	C
0.00003500	1047.	29926174.	10.6945711	0.0003743	-0.0001857	1.6064521	10.7737898	10.7737898	C
0.00003625	1080.	29795785.	10.5778505	0.0003834	-0.0001966	1.6416633	11.0358654	11.0358654	C
0.00003750	1113.	29671537.	10.4684931	0.0003926	-0.0002074	1.6766302	11.2974864	11.2974864	C
0.00003875	1145.	29551820.	10.3655299	0.0004017	-0.0002183	1.7113156	11.5583644	11.5583644	C
0.00004000	1178.	29437570.	10.2686552	0.0004107	-0.0002293	1.7457661	11.8188402	11.8188402	C
0.00004125	1210.	29328510.	10.1773685	0.0004198	-0.0002402	1.7799906	12.0789772	12.0789772	C
0.00004250	1242.	29223374.	10.0909482	0.0004289	-0.0002511	1.8139533	12.3384937	12.3384937	C
0.00004375	1274.	29123427.	10.0093901	0.0004379	-0.0002621	1.8477234	12.5979139	12.5979139	C
0.00004500	1306.	29026678.	9.9318541	0.0004469	-0.0002731	1.8812278	12.8566697	12.8566697	C
0.00004625	1338.	28934607.	9.8584898	0.0004560	-0.0002840	1.9145498	13.1153995	13.1153995	C
0.00004750	1370.	28845622.	9.7886067	0.0004650	-0.0002950	1.9476260	13.3736058	13.3736058	C
0.00004875	1402.	28760424.	9.7222096	0.0004740	-0.0003060	1.9805064	13.6316740	13.6316740	C
0.00005125	1466.	28599497.	9.5985816	0.0004919	-0.0003281	2.0456301	14.1469920	14.1469920	C
0.00005375	1529.	28450633.	9.4860128	0.0005099	-0.0003501	2.1099585	14.6616225	14.6616225	C
0.00005625	1593.	28312206.	9.3829983	0.0005278	-0.0003722	2.1734881	15.1755161	15.1755161	C
0.00005875	1656.	28182925.	9.2882857	0.0005457	-0.0003943	2.2362154	15.6886169	15.6886169	C
0.00006125	1719.	28062836.	9.2012760	0.0005636	-0.0004164	2.2982326	16.2016666	16.2016666	C
0.00006375	1782.	27949536.	9.1205330	0.0005814	-0.0004386	2.3594236	16.7136855	16.7136855	C
0.00006625	1845.	27843986.	9.0460190	0.0005993	-0.0004607	2.4199443	17.2259642	17.2259642	C
0.00006875	1907.	27744086.	8.9765219	0.0006171	-0.0004829	2.4796702	17.7374408	17.7374408	C
0.00007125	1970.	27650365.	8.9119888	0.0006350	-0.0005050	2.5387173	18.2490971	18.2490971	C
0.00007375	2033.	27561798.	8.8517266	0.0006528	-0.0005272	2.5970392	18.7605306	18.7605306	C
0.00007625	2095.	27477831.	8.7952921	0.0006706	-0.0005494	2.6546312	19.2716900	19.2716900	C
0.00007875	2158.	27398544.	8.7425633	0.0006885	-0.0005715	2.7115555	19.7831292	19.7831292	C
0.00008125	2220.	27323076.	8.6929762	0.0007063	-0.0005937	2.7677540	20.2943253	20.2943253	C
0.00008375	2282.	27251162.	8.6462892	0.0007241	-0.0006159	2.8232380	20.8053750	20.8053750	C
0.00008625	2345.	27182822.	8.6024210	0.0007420	-0.0006380	2.8780537	21.3167057	21.3167057	C
0.00008875	2407.	27117752.	8.5611337	0.0007598	-0.0006602	2.9322000	21.8283182	21.8283182	C
0.00009125	2469.	27055148.	8.5219030	0.0007776	-0.0006824	2.9855900	22.3393861	22.3393861	C
0.00009375	2531.	26995319.	8.4848597	0.0007955	-0.0007045	3.0383082	22.8507125	22.8507125	C
0.00009625	2593.	26938063.	8.4498422	0.0008133	-0.0007267	3.0903560	23.3623224	23.3623224	C
0.00009875	2655.	26883181.	8.4166970	0.0008311	-0.0007489	3.1417323	23.8742164	23.8742164	C
0.0001013	2717.	26830317.	8.3851638	0.0008490	-0.0007710	3.1924010	24.3860376	24.3860376	C
0.0001038	2778.	26779305.	8.3551138	0.0008668	-0.0007932	3.2423586	24.8977490	24.8977490	C
0.0001063	2840.	26730206.	8.3265709	0.0008847	-0.0008153	3.2916435	25.4097468	25.4097468	C
0.0001088	2902.	26682886.	8.2994314	0.0009026	-0.0008374	3.3402547	25.9220319	25.9220319	C
0.0001113	2963.	26637225.	8.2736009	0.0009204	-0.0008596	3.3881910	26.4346052	26.4346052	C
0.0001138	3025.	26593112.	8.2489934	0.0009383	-0.0008817	3.4354512	26.9474673	26.9474673	C

0.0001163	3086.	26550292.	8.2254095	0.0009562	-0.0009038	3.4819977	27.4602120	27.4602120	C
0.0001188	3148.	26508744.	8.2028312	0.0009741	-0.0009259	3.5278452	27.9730004	27.9730004	C
0.0001213	3209.	26468478.	8.1812670	0.0009920	-0.0009480	3.5730151	28.4860806	28.4860806	C
0.0001238	3271.	26429414.	8.1606557	0.0010099	-0.0009701	3.6175064	28.9994534	28.9994534	C
0.0001263	3332.	26391480.	8.1409408	0.0010278	-0.0009922	3.6613180	29.5131198	29.5131198	C
0.0001288	3393.	26354609.	8.1220704	0.0010457	-0.0010143	3.7044486	30.0270806	30.0270806	C
0.0001313	3454.	26318739.	8.1039964	0.0010636	-0.0010364	3.7468971	30.5413367	30.5413367	C
0.0001338	3515.	26283813.	8.0866745	0.0010816	-0.0010584	3.7886624	31.0558890	31.0558890	C
0.0001363	3577.	26249691.	8.0699793	0.0010995	-0.0010805	3.8297172	31.5704063	31.5704063	C
0.0001388	3638.	26216359.	8.0539058	0.0011175	-0.0011025	3.8700703	32.0850037	32.0850037	C
0.0001413	3698.	26183830.	8.0384743	0.0011354	-0.0011246	3.9097384	32.5999009	32.5999009	C
0.0001438	3759.	26152061.	8.0236518	0.0011534	-0.0011466	3.9487203	33.1150987	33.1150987	C
0.0001463	3820.	26121011.	8.0094071	0.0011714	-0.0011686	3.9870146	33.6305981	33.6305981	C
0.0001488	3881.	26090644.	7.9957113	0.0011894	-0.0011906	4.0246204	-34.1834000	-34.1834000	C
0.0001588	4124.	25975337.	7.9459032	0.0012614	-0.0012786	4.1681336	-36.7107478	-36.7107478	C
0.0001688	4365.	25868416.	7.9028560	0.0013336	-0.0013664	4.3004891	-39.2338981	-39.2338981	C
0.0001788	4606.	25768386.	7.8653924	0.0014059	-0.0014541	4.4216050	-41.7530714	-41.7530714	C
0.0001888	4846.	25674249.	7.8328245	0.0014784	-0.0015416	4.5314697	-44.2671765	-44.2671765	C
0.0001988	5085.	25585063.	7.8044248	0.0015511	-0.0016289	4.6300018	-46.7761462	-46.7761462	C
0.0002088	5323.	25500066.	7.7796057	0.0016240	-0.0017160	4.7171179	-49.2799116	-49.2799116	C
0.0002188	5551.	25375430.	7.7532043	0.0016960	-0.0018040	4.7917431	-51.8081098	-50.0000000	CY
0.0002288	5742.	25099514.	7.7137220	0.0017645	-0.0018955	4.8521064	-54.4383963	50.0000000	CY
0.0002388	5896.	24694525.	7.6727721	0.0018319	-0.0019881	4.9014066	-57.1017434	50.0000000	CY
0.0002488	6021.	24205988.	7.6373432	0.0018998	-0.0020802	4.9410314	-59.7490150	50.0000000	CY
0.0002588	6126.	23676682.	7.6061196	0.0019681	-0.0021719	4.9706663	-60.0000000	50.0000000	CY
0.0002688	6218.	23134961.	7.5770846	0.0020363	-0.0022637	4.9900509	-60.0000000	50.0000000	CY
0.0002788	6297.	22590712.	7.5498276	0.0021045	-0.0023555	4.9991985	60.0000000	50.0000000	CY
0.0002888	6368.	22052491.	7.5250280	0.0021729	-0.0024471	4.9999677	60.0000000	50.0000000	CY
0.0002988	6430.	21524463.	7.5017893	0.0022412	-0.0025388	4.9986185	60.0000000	50.0000000	CY
0.0003088	6487.	21010616.	7.4803817	0.0023096	-0.0026304	4.9994732	60.0000000	50.0000000	CY
0.0003188	6538.	20511344.	7.4605536	0.0023781	-0.0027219	4.9998548	60.0000000	50.0000000	CY
0.0003288	6584.	20027151.	7.4421278	0.0024466	-0.0028134	4.9999800	60.0000000	50.0000000	CY
0.0003388	6626.	19559111.	7.4249269	0.0025152	-0.0029048	4.9999999	60.0000000	50.0000000	CY
0.0003488	6664.	19106927.	7.4091688	0.0025839	-0.0029961	4.9996751	60.0000000	50.0000000	CY
0.0003588	6698.	18670412.	7.3948236	0.0026529	-0.0030871	4.9999980	60.0000000	50.0000000	CY
0.0003688	6730.	18249855.	7.3816067	0.0027220	-0.0031780	4.9999533	60.0000000	50.0000000	CY
0.0003788	6759.	17844961.	7.3693882	0.0027912	-0.0032688	4.9997584	60.0000000	50.0000000	CY
0.0003888	6785.	17453779.	7.3581971	0.0028605	-0.0033595	4.9992449	60.0000000	50.0000000	CY
0.0003988	6809.	17077096.	7.3479944	0.0029300	-0.0034500	4.9981830	60.0000000	50.0000000	CY
0.0004088	6832.	16714976.	7.3385096	0.0029996	-0.0035404	4.9965403	60.0000000	50.0000000	CY
0.0004188	6853.	16365276.	7.3303725	0.0030696	-0.0036304	4.9998683	60.0000000	50.0000000	CY
0.0004288	6872.	16028209.	7.3224222	0.0031395	-0.0037205	4.9987959	60.0000000	50.0000000	CY
0.0004388	6890.	15703333.	7.3155942	0.0032097	-0.0038103	4.9962833	60.0000000	50.0000000	CY
0.0004488	6906.	15390205.	7.3092286	0.0032800	-0.0039000	4.9997921	60.0000000	50.0000000	CY
0.0004588	6921.	15087670.	7.3035906	0.0033505	-0.0039895	4.9979317	60.0000000	50.0000000	CY
0.0004688	6936.	14796423.	7.2984876	0.0034212	-0.0040788	4.9999999	60.0000000	50.0000000	CY
0.0004788	6949.	14514281.	7.2939910	0.0034920	-0.0041680	4.9986991	60.0000000	50.0000000	CY

0.0004888	6961.	14242845.	7.2898596	0.0035629	-0.0042571	4.9967607	60.0000000	50.0000000	CY
0.0004988	6972.	13979418.	7.2864556	0.0036341	-0.0043459	4.9989269	60.0000000	50.0000000	CY
0.0005088	6983.	13725603.	7.2833098	0.0037054	-0.0044346	4.9959337	60.0000000	50.0000000	CY
0.0005188	6993.	13479770.	7.2807035	0.0037769	-0.0045231	4.9987346	60.0000000	50.0000000	CY
0.0005288	7002.	13241905.	7.2783882	0.0038484	-0.0046116	4.9976792	60.0000000	50.0000000	CY

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	166.100	6832.360	0.00300000

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	6832.	107.965000	4441.	25836954.
1	0.70	6832.	116.270000	4783.	25699111.
1	0.75	6832.	124.575000	5124.	25571056.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	2.0000	0.00	N.A.	No	0.00	2719576.
2	62.0000	60.0000	No	No	2719576.	0.00
3	69.0000	67.0000	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)

```
Displacement of pile head          =     0.740000 inches
Moment at pile head                =          0.0 in-lbs
Axial load at pile head            =     166100.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7400	0.00	14169.	-0.00625	0.00	3.25E+10	0.00	0.00	0.00
0.5000	0.7025	91241.	14169.	-0.00624	0.00	3.25E+10	0.00	0.00	0.00
1.0000	0.6651	182465.	14169.	-0.00621	0.00	3.25E+10	0.00	0.00	0.00
1.5000	0.6280	273656.	14169.	-0.00617	0.00	3.25E+10	0.00	0.00	0.00
2.0000	0.5911	364796.	14169.	-0.00611	0.00	3.25E+10	0.00	0.00	0.00
2.5000	0.5546	455870.	14088.	-0.00604	0.00	3.25E+10	-27.1353	293.5638	0.00
3.0000	0.5186	545882.	13834.	-0.00594	0.00	3.25E+10	-57.5845	666.1818	0.00
3.5000	0.4833	633721.	13399.	-0.00584	0.00	3.25E+10	-87.1762	1082.	0.00
4.0000	0.4486	718304.	12799.	-0.00571	0.00	3.25E+10	-112.8119	1509.	0.00
4.5000	0.4148	798694.	12054.	-0.00557	0.00	3.24E+10	-135.5305	1961.	0.00
5.0000	0.3818	874058.	11190.	-0.00541	0.00	3.07E+10	-152.6338	2399.	0.00
5.5000	0.3498	943757.	10238.	-0.00523	0.00	3.04E+10	-164.5764	2823.	0.00

Pier Micropile

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches

6.0000	0.3190	1007345.	9227.	-0.00504	0.00	3.01E+10	-172.5674	3246.	0.00
6.5000	0.2894	1064521.	8157.	-0.00483	0.00	2.99E+10	-184.0287	3816.	0.00
7.0000	0.2610	1114859.	7040.	-0.00461	0.00	2.97E+10	-188.4225	4331.	0.00
7.5000	0.2340	1158188.	5900.	-0.00438	0.00	2.95E+10	-191.3934	4907.	0.00
8.0000	0.2085	1194393.	4715.	-0.00414	0.00	2.94E+10	-203.7466	5865.	0.00
8.5000	0.1843	1223020.	3466.	-0.00389	0.00	2.93E+10	-212.5017	6917.	0.00
9.0000	0.1617	1243747.	2163.	-0.00364	0.00	2.92E+10	-221.9935	8236.	0.00
9.5000	0.1406	1256227.	803.5289	-0.00338	0.00	2.92E+10	-231.0131	9855.	0.00
10.0000	0.1211	1260134.	-601.1231	-0.00313	0.00	2.92E+10	-237.2042	11751.	0.00
10.5000	0.1031	1255243.	-2034.	-0.00287	0.00	2.92E+10	-240.3338	13980.	0.00
11.0000	0.08672	1241443.	-3475.	-0.00261	0.00	2.92E+10	-240.2023	16619.	0.00
11.5000	0.07182	1218741.	-4906.	-0.00236	0.00	2.93E+10	-236.6397	19769.	0.00
12.0000	0.05842	1187272.	-6304.	-0.00211	0.00	2.94E+10	-229.4973	23569.	0.00
12.5000	0.04648	1147299.	-7649.	-0.00187	0.00	2.95E+10	-218.6324	28223.	0.00
13.0000	0.03593	1099224.	-8916.	-0.00165	0.00	2.97E+10	-203.8803	34044.	0.00
13.5000	0.02672	1043587.	-10075.	-0.00143	0.00	2.99E+10	-182.5074	40986.	0.00
14.0000	0.01876	981172.	-11024.	-0.00123	0.00	3.02E+10	-133.6991	42768.	0.00
14.5000	0.01197	913750.	-11692.	-0.00104	0.00	3.05E+10	-88.8444	44550.	0.00
15.0000	0.00625	842950.	-12103.	-8.74E-04	0.00	3.24E+10	-48.2796	46332.	0.00
15.5000	0.00147	770256.	-12283.	-7.25E-04	0.00	3.24E+10	-11.8249	48114.	0.00
16.0000	-0.00245	696995.	-12258.	-5.89E-04	0.00	3.25E+10	20.3601	49896.	0.00
16.5000	-0.00560	624339.	-12052.	-4.67E-04	0.00	3.25E+10	48.2162	51678.	0.00
17.0000	-0.00806	553303.	-11692.	-3.58E-04	0.00	3.25E+10	71.7740	53460.	0.00
17.5000	-0.00990	484749.	-11203.	-2.63E-04	0.00	3.25E+10	91.1429	55242.	0.00
18.0000	-0.01121	419387.	-10610.	-1.79E-04	0.00	3.25E+10	106.4988	57024.	0.00
18.5000	-0.01205	357782.	-9937.	-1.07E-04	0.00	3.25E+10	118.0733	58806.	0.00
19.0000	-0.01249	300361.	-9204.	-4.64E-05	0.00	3.25E+10	126.1418	60588.	0.00
19.5000	-0.01260	247427.	-8433.	4.25E-06	0.00	3.25E+10	131.0127	62370.	0.00
20.0000	-0.01244	199163.	-7640.	4.55E-05	0.00	3.25E+10	133.0169	64152.	0.00
20.5000	-0.01206	155651.	-6844.	7.83E-05	0.00	3.25E+10	132.4980	65934.	0.00
21.0000	-0.01150	116880.	-6057.	1.03E-04	0.00	3.25E+10	129.8036	67716.	0.00
21.5000	-0.01082	82761.	-5292.	1.22E-04	0.00	3.25E+10	125.2780	69498.	0.00
22.0000	-0.01004	53137.	-4558.	1.34E-04	0.00	3.25E+10	119.2550	71280.	0.00
22.5000	-0.00920	27796.	-3864.	1.42E-04	0.00	3.25E+10	112.0529	73062.	0.00
23.0000	-0.00833	6484.	-3216.	1.45E-04	0.00	3.25E+10	103.9697	74844.	0.00
23.5000	-0.00746	-11087.	-2618.	1.45E-04	0.00	3.25E+10	95.2796	76626.	0.00
24.0000	-0.00660	-25225.	-2074.	1.41E-04	0.00	3.25E+10	86.2308	78408.	0.00
24.5000	-0.00576	-36255.	-1584.	1.36E-04	0.00	3.25E+10	77.0438	80190.	0.00
25.0000	-0.00497	-44504.	-1149.	1.28E-04	0.00	3.25E+10	67.9105	81972.	0.00
25.5000	-0.00423	-50300.	-768.4484	1.19E-04	0.00	3.25E+10	58.9943	83754.	0.00
26.0000	-0.00354	-53964.	-440.1723	1.10E-04	0.00	3.25E+10	50.4310	85536.	0.00
26.5000	-0.00291	-55801.	-161.8915	9.97E-05	0.00	3.25E+10	42.3293	87318.	0.00
27.0000	-0.00234	-56105.	69.4142	8.93E-05	0.00	3.25E+10	34.7726	89100.	0.00
27.5000	-0.00184	-55146.	257.1963	7.90E-05	0.00	3.25E+10	27.8214	90882.	0.00
28.0000	-0.00139	-53176.	405.2040	6.90E-05	0.00	3.25E+10	21.5145	92664.	0.00
28.5000	-0.00101	-50422.	517.3637	5.95E-05	0.00	3.25E+10	15.8721	94446.	0.00
29.0000	-6.79E-04	-47086.	597.6729	5.05E-05	0.00	3.25E+10	10.8977	96228.	0.00

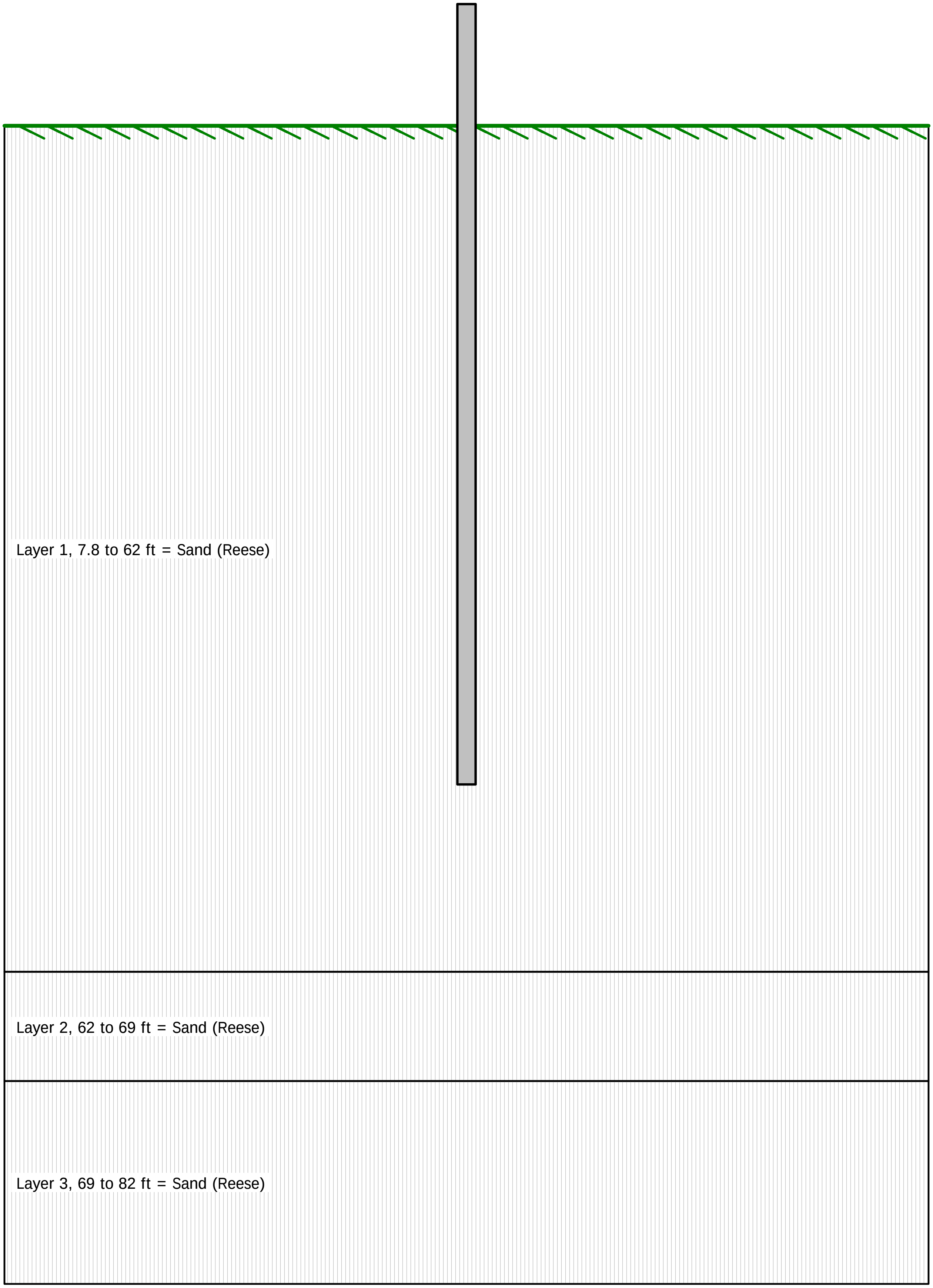
29.5000	-4.03E-04	-43350.	650.1078	4.21E-05	0.00	3.25E+10	6.5807	98010.	0.00
30.0000	-1.74E-04	-39369.	678.5458	3.45E-05	0.00	3.25E+10	2.8987	99792.	0.00
30.5000	1.06E-05	-35276.	686.7013	2.76E-05	0.00	3.25E+10	-0.1802	101574.	0.00
31.0000	1.56E-04	-31183.	678.0753	2.14E-05	0.00	3.25E+10	-2.6952	103356.	0.00
31.5000	2.68E-04	-27182.	655.9170	1.60E-05	0.00	3.25E+10	-4.6910	105138.	0.00
32.0000	3.49E-04	-23344.	623.1967	1.14E-05	0.00	3.25E+10	-6.2158	106920.	0.00
32.5000	4.04E-04	-19726.	582.5894	7.38E-06	0.00	3.25E+10	-7.3200	108702.	0.00
33.0000	4.37E-04	-16368.	536.4669	4.05E-06	0.00	3.25E+10	-8.0542	110484.	0.00
33.5000	4.53E-04	-13297.	486.8983	1.31E-06	0.00	3.25E+10	-8.4687	112266.	0.00
34.0000	4.53E-04	-10528.	435.6561	-8.95E-07	0.00	3.25E+10	-8.6120	114048.	0.00
34.5000	4.42E-04	-8067.	384.2291	-2.61E-06	0.00	3.25E+10	-8.5303	115830.	0.00
35.0000	4.22E-04	-5912.	333.8382	-3.90E-06	0.00	3.25E+10	-8.2666	117612.	0.00
35.5000	3.95E-04	-4053.	285.4567	-4.82E-06	0.00	3.25E+10	-7.8606	119394.	0.00
36.0000	3.64E-04	-2477.	239.8315	-5.43E-06	0.00	3.25E+10	-7.3479	121176.	0.00
36.5000	3.30E-04	-1164.	197.5068	-5.76E-06	0.00	3.25E+10	-6.7604	122958.	0.00
37.0000	2.95E-04	-95.2203	158.8480	-5.88E-06	0.00	3.25E+10	-6.1259	124740.	0.00
37.5000	2.59E-04	753.4719	124.0658	-5.82E-06	0.00	3.25E+10	-5.4682	126522.	0.00
38.0000	2.25E-04	1405.	93.2387	-5.62E-06	0.00	3.25E+10	-4.8075	128304.	0.00
38.5000	1.92E-04	1884.	66.3365	-5.32E-06	0.00	3.25E+10	-4.1600	130086.	0.00
39.0000	1.61E-04	2212.	43.2403	-4.94E-06	0.00	3.25E+10	-3.5388	131868.	0.00
39.5000	1.33E-04	2412.	23.7621	-4.51E-06	0.00	3.25E+10	-2.9539	133650.	0.00
40.0000	1.07E-04	2506.	7.6628	-4.06E-06	0.00	3.25E+10	-2.4125	135432.	0.00
40.5000	8.39E-05	2512.	-5.3331	-3.59E-06	0.00	3.25E+10	-1.9194	137214.	0.00
41.0000	6.38E-05	2449.	-15.5228	-3.13E-06	0.00	3.25E+10	-1.4772	138996.	0.00
41.5000	4.63E-05	2332.	-23.2144	-2.69E-06	0.00	3.25E+10	-1.0867	140778.	0.00
42.0000	3.14E-05	2176.	-28.7161	-2.28E-06	0.00	3.25E+10	-0.7472	142560.	0.00
42.5000	1.90E-05	1992.	-32.3289	-1.89E-06	0.00	3.25E+10	-0.4570	144342.	0.00
43.0000	8.75E-06	1792.	-34.3394	-1.54E-06	0.00	3.25E+10	-0.2132	146124.	0.00
43.5000	4.96E-07	1583.	-35.0156	-1.23E-06	0.00	3.25E+10	-0.01222	147906.	0.00
44.0000	-6.01E-06	1374.	-34.6027	-9.57E-07	0.00	3.25E+10	0.1498	149688.	0.00
44.5000	-1.10E-05	1170.	-33.3212	-7.22E-07	0.00	3.25E+10	0.2773	151470.	0.00
45.0000	-1.47E-05	975.5734	-31.3654	-5.23E-07	0.00	3.25E+10	0.3746	153252.	0.00
45.5000	-1.73E-05	794.5561	-28.9030	-3.60E-07	0.00	3.25E+10	0.4462	155034.	0.00
46.0000	-1.90E-05	629.4544	-26.0759	-2.28E-07	0.00	3.25E+10	0.4962	156816.	0.00
46.5000	-2.00E-05	482.1009	-23.0006	-1.26E-07	0.00	3.25E+10	0.5289	158598.	0.00
47.0000	-2.05E-05	353.6978	-19.7705	-4.85E-08	0.00	3.25E+10	0.5478	160380.	0.00
47.5000	-2.06E-05	244.9512	-16.4576	6.83E-09	0.00	3.25E+10	0.5565	162162.	0.00
48.0000	-2.04E-05	156.1924	-13.1150	4.39E-08	0.00	3.25E+10	0.5578	163944.	0.00
48.5000	-2.01E-05	87.4841	-9.7792	6.64E-08	0.00	3.25E+10	0.5542	165726.	0.00
49.0000	-1.96E-05	38.7092	-6.4739	7.81E-08	0.00	3.25E+10	0.5476	167508.	0.00
49.5000	-1.91E-05	9.6420	-3.2121	8.25E-08	0.00	3.25E+10	0.5396	169290.	0.00
50.0000	-1.86E-05	0.00	0.00	8.34E-08	0.00	3.25E+10	0.5310	85536.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be inter-

```
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 1:

Pile-head deflection               =     0.74000000 inches
Computed slope at pile head        =    -0.00624727 radians
Maximum bending moment             =       1260134. inch-lbs
Maximum shear force                =         14169. lbs
Depth of maximum bending moment    =    10.00000000 feet below pile head
Depth of maximum shear force       =     0.50000000 feet below pile head
Number of iterations               =              8
Number of zero deflection points   =              3


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                 Axial    Pile-head  Pile-head  Max Shear Max Moment
Case Type   Pile-head    Type     Pile-head  Loading  Deflection  Rotation    in Pile    in Pile
 No.  1      Load 1       2        Load 2      lbs      inches     radians      lbs       in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
  1  y, in     0.7400  M, in-lb       0.00    166100.     0.7400   -0.00625     14169.   1260134.


Maximum pile-head deflection = 0.7400000000 inches
Maximum pile-head rotation   = -0.0062472667 radians = -0.357942 deg.

The analysis ended normally.
```

Pier Micropile - Scoured

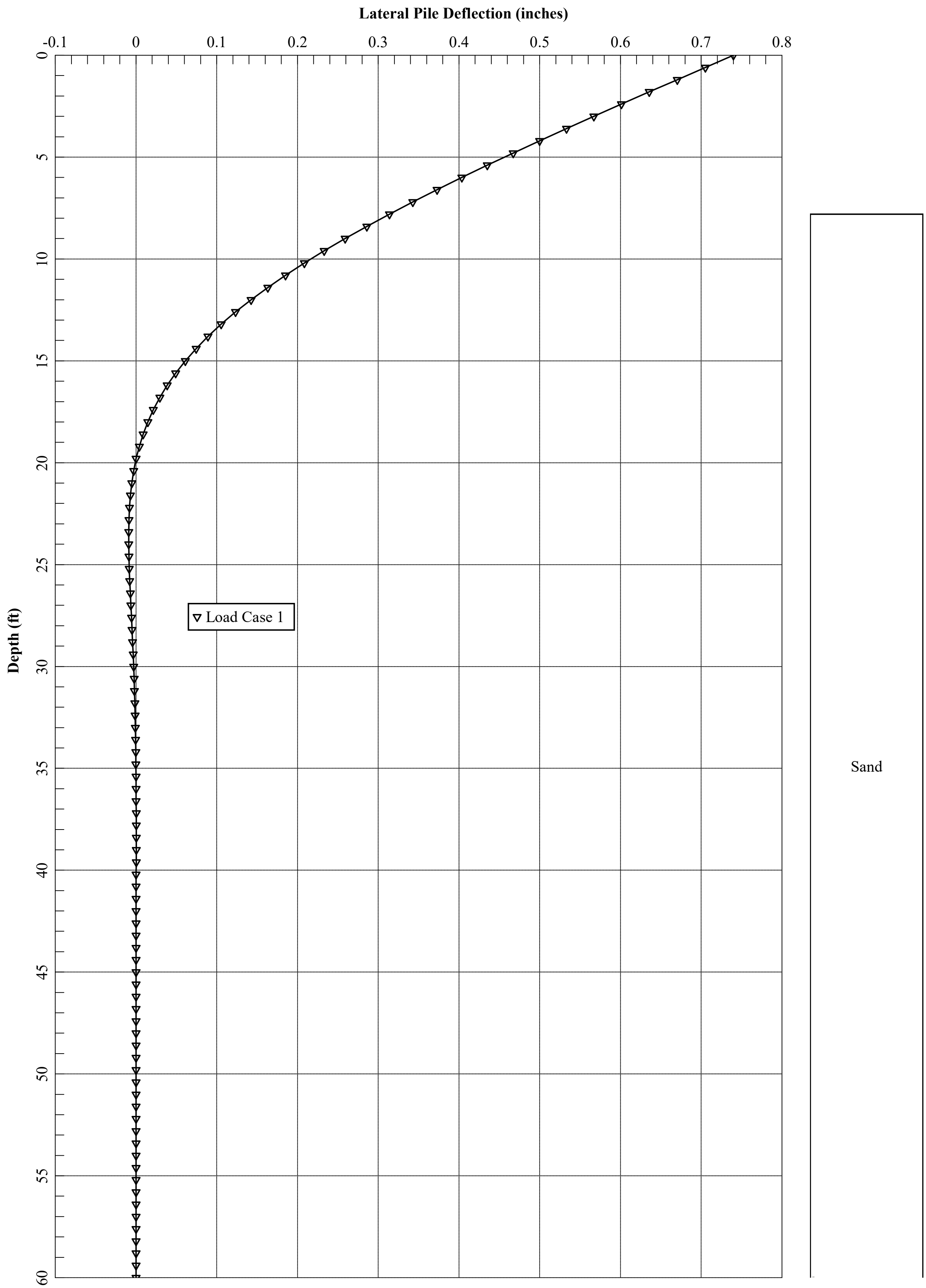
Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



LPile 2018.10.09, © 2018 by Ensoft, Inc.

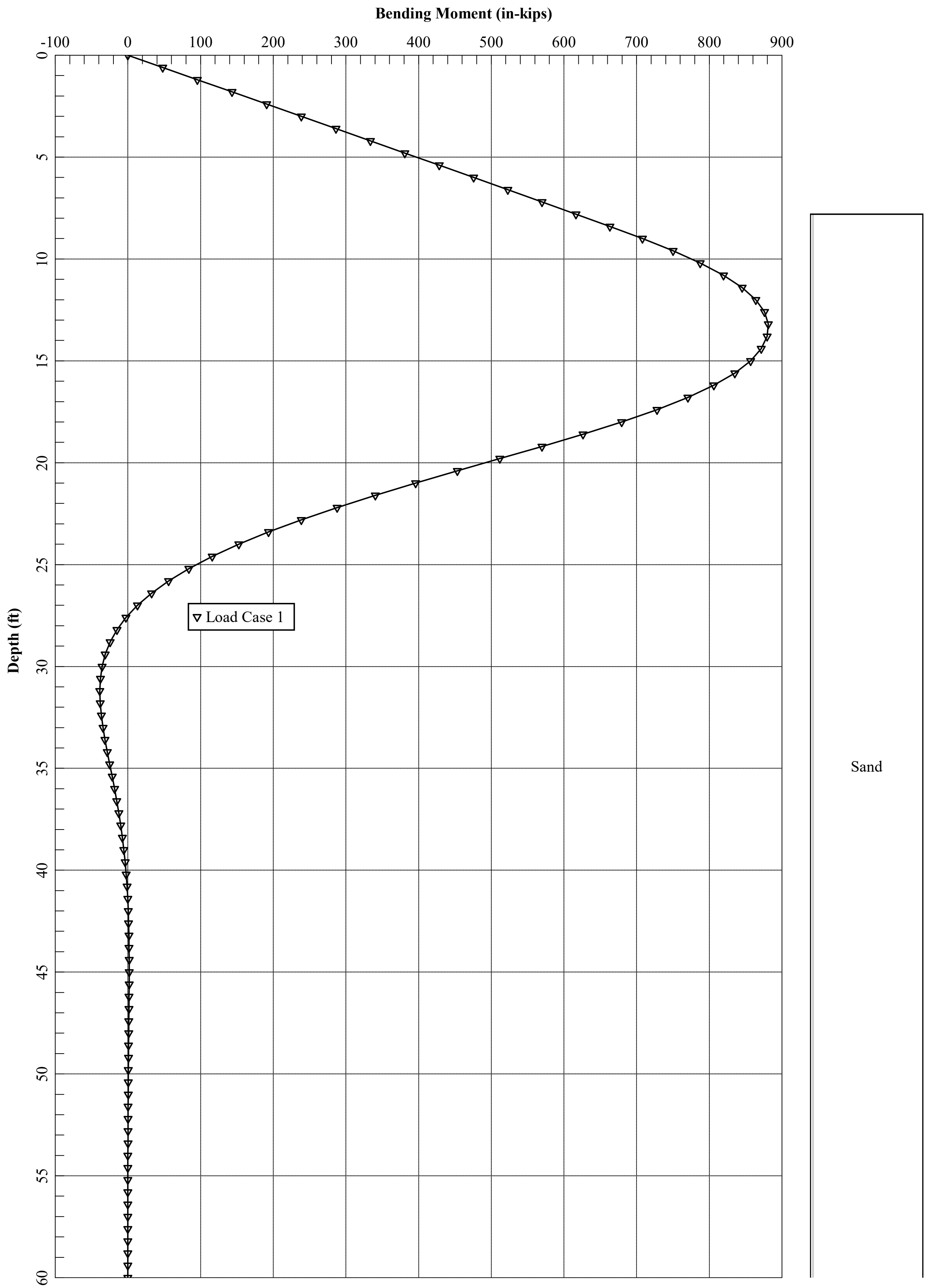
Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



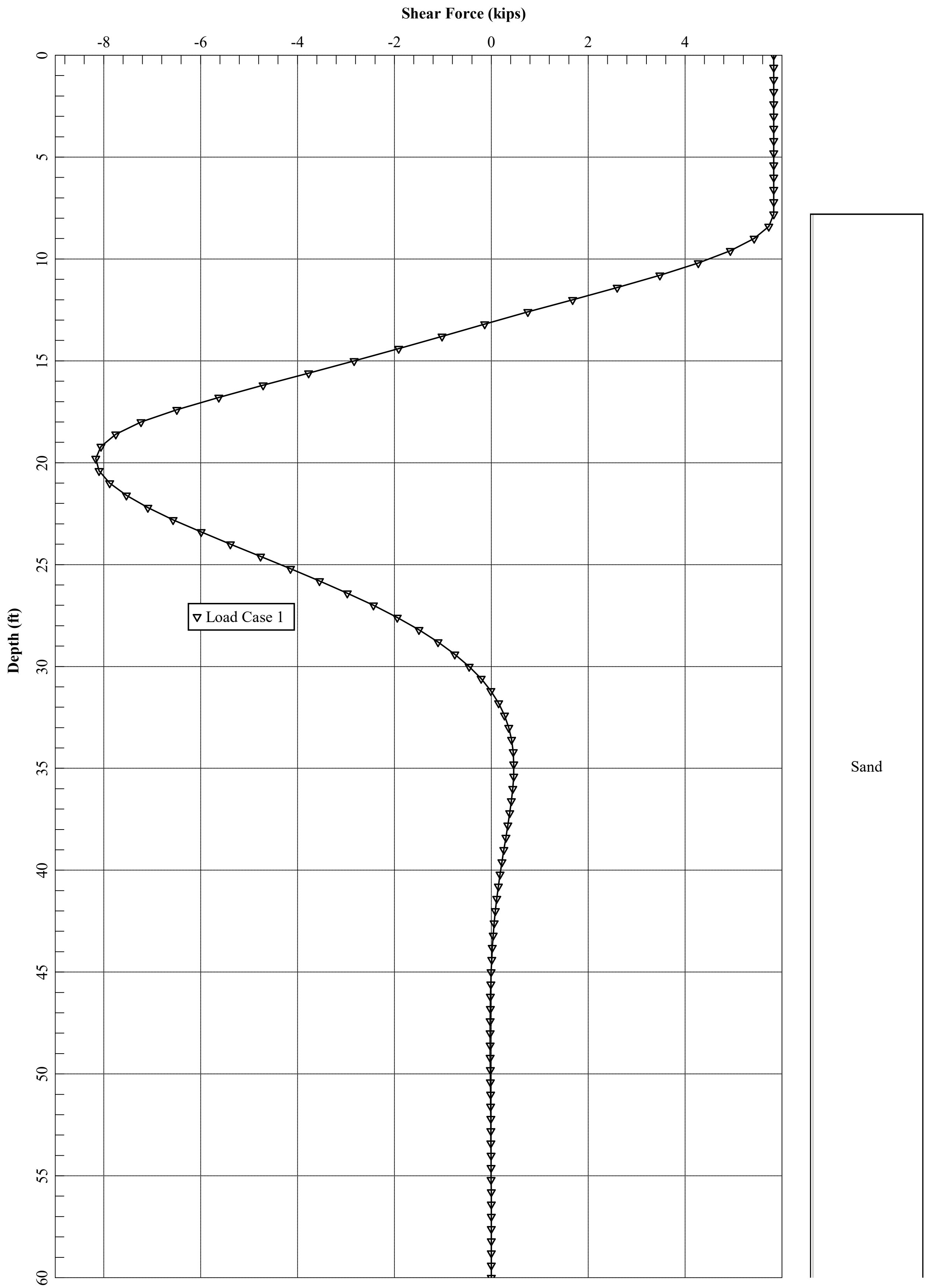
Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



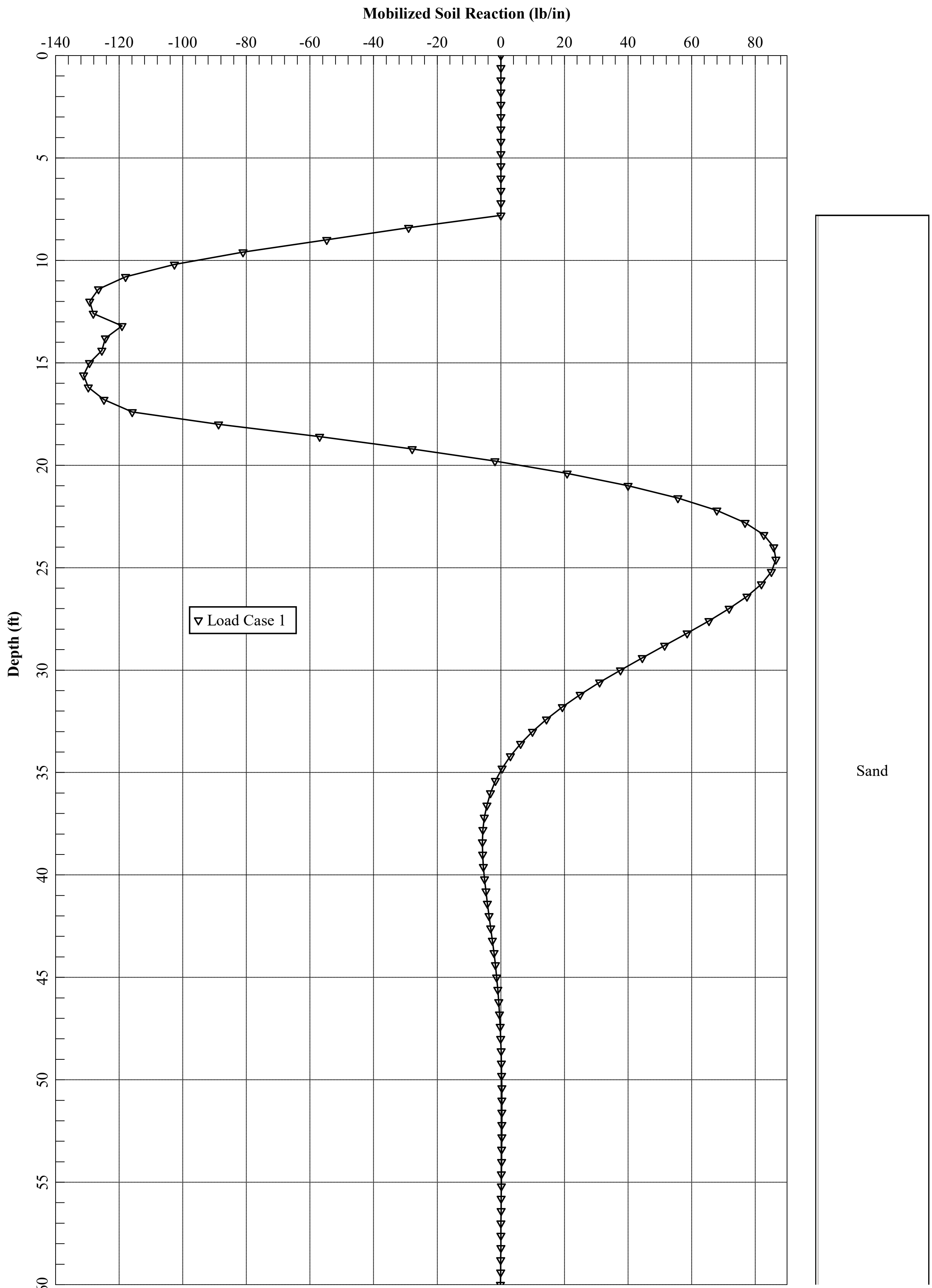
Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches



```
================================================================================

                 LPile for Windows(Beta), Version 2018-10.009

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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--------------------------------------------------------------------------------
                                     Files Used for Analysis
       --------------------------------------------------------------------------------

Path to file locations:
\Working\HDR\1703257 HDR-MASSDOT RR BRIDGES\08_Letters and Reports\MP 79.90\Calculations\LPILE
\

Name of input data file:
2a. Pier Micropile Scoured.lp10

Name of output report file:
2a. Pier Micropile Scoured.lp10

Name of plot output file:
2a. Pier Micropile Scoured.lp10

Name of runtime message file:
2a. Pier Micropile Scoured.lp10
```

Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches

```
--------------------------------------------------------------------------------
                            Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  March 27, 2020              Time:  10:23:06


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: Br. 79.90, HDR-MassDOT Railroad Bridges

Job Number: 1703257

Client: HDR

Engineer: WGL

Description: HP14x117_Bridge Abutment



--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified
```

- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =            1
Total length of pile                                   =       60.000 ft
Depth of ground surface below top of pile              =       7.8000 ft
```

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	16.0000
2	60.000	16.0000

Input Structural Properties for Pile Sections:

```
---------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                =    60.000000 ft
   Casing outside diameter                          =    16.000000 in
   Shear capacity of section                        =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =     7.800000 ft
   Distance from top of pile to bottom of layer     =    62.000000 ft
   Effective unit weight at top of layer            =    57.600000 pcf
   Effective unit weight at bottom of layer         =    57.600000 pcf
   Friction angle at top of layer                   =    32.000000 deg.
   Friction angle at bottom of layer                =    32.000000 deg.
   Subgrade k at top of layer                       =    55.000000 pci
   Subgrade k at bottom of layer                    =    55.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =    62.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    69.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    35.000000 deg.
   Friction angle at bottom of layer                   =    35.000000 deg.
   Subgrade k at top of layer                          =    86.000000 pci
   Subgrade k at bottom of layer                       =    86.000000 pci


Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    69.000000 ft
   Distance from top of pile to bottom of layer        =    82.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Friction angle at top of layer                      =    38.000000 deg.
   Friction angle at bottom of layer                   =    38.000000 deg.
   Subgrade k at top of layer                          =   120.000000 pci
   Subgrade k at bottom of layer                       =   120.000000 pci


 (Depth of the lowest soil layer extends 22.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of
Layer           Name             Depth      Unit Wt.     Friction         kpy
 Num.     (p-y Curve Type)        ft          pcf          deg.           pci
-----   -------------------   ----------   ----------   ----------   ----------
  1            Sand              7.8000      57.6000      32.0000      55.0000
          (Reese, et al.)       62.0000      57.6000      32.0000      55.0000
  2            Sand             62.0000      67.6000      35.0000      86.0000
          (Reese, et al.)       69.0000      67.6000      35.0000      86.0000
  3            Sand             69.0000      72.6000      38.0000     120.0000
          (Reese, et al.)       82.0000      72.6000      38.0000     120.0000


--------------------------------------------------------------------------------
                    p-y Modification Factors for Group Action
--------------------------------------------------------------------------------
```

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	8.700	0.9000	1.0000
2	50.000	0.9000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	4	y = 0.740000 in	M = 0.0000 in-lbs	166100.	N.A.

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

```
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:
--------------------------------------------------------------------------------

Length of Section                                    =    60.000000 ft
Outer Diameter of Casing                             =    16.000000 in
Concrete Cover Thickness Inside Casing               =     3.000000 in
Casing Wall Thickness                                =     0.500000 in
Moment of Inertia of Steel Casing                    =   731.942001 in^4
Yield Stress of Casing                               =       50000. psi
Elastic Modulus of Casing                            =    29000000. psi
Number of Reinforcing Bars                           =            1 bar
Area of Single Reinforcing Bar                       =     4.000000 sq. in.
Edge-to-Edge Bar Spacing                             =    -2.257000 in
Maximum Concrete Aggregate Size                      =     0.750000 in
Ratio of Bar Spacing to Aggregate Size               =        -3.01
Offset of Center of Rebar Cage from Center of Pile   =       0.0000 in
Yield Stress of Reinforcing Bars                     =       60000. psi
Modulus of Elasticity of Reinforcing Bars            =    29000000. psi
Gross Area of Pile                                   =   201.061930 sq. in.
Area of Concrete                                     =   172.714587 sq. in.
Cross-sectional Area of Steel Casing                 =    24.347343 sq. in.
Area of All Steel (Casing and Bars)                  =    28.347343 sq. in.
Area Ratio of All Steel to Gross Area of Pile        =        14.10 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As  =     2191.404 kips
Tensile Load for Cracking of Concrete                =     -174.557 kips
Nominal Axial Tensile Capacity                       =    -1457.367 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X              Y
```

```
    Number        inches        sq. in.       inches        inches
  ----------    ----------    ----------    ----------    ----------
      1          2.257000      4.000000       0.00000       0.00000


NOTE: The positions of the above rebars were computed by LPile


Concrete Properties:
--------------------

Compressive Strength of Concrete                          =        5000. psi
Modulus of Elasticity of Concrete                         =     4030509. psi
Modulus of Rupture of Concrete                            =  -530.330086 psi
Compression Strain at Peak Stress                         =     0.002109
Tensile Strain at Fracture of Concrete                    =   -0.0001150
Maximum Coarse Aggregate Size                             =     0.750000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              166.100


Definitions of Run Messages and Notes:
--------------------------------------

  C = concrete in section has cracked in tension.
  Y = stress in reinforcing steel has reached yield stress.
  T = ACI 318 criteria for tension-controlled section met, tensile strain in
      reinforcement exceeds 0.005 while simultaneously compressive strain in
      concrete more than 0.003. See ACI 318, Section 10.3.4.
  Z = depth of tensile zone in concrete section is less than 10 percent of
      section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.
```

Pier Micropile - Scoured

Axial Load: 166.1 kips
Applied Displacement at Pile Head: 0.74 inches

Axial Thrust Force = 166.100 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	40.5891926	32471354.	89.9685551	0.0001125	0.00009246	0.5185959	3.2584601	3.2584601	
0.00000250	81.1770662	32470826.	48.9875440	0.0001225	0.00008247	0.5629647	3.5457970	3.5457970	
0.00000375	121.7647117	32470590.	35.3286604	0.0001325	0.00007248	0.6071369	3.8332918	3.8332918	
0.00000500	162.3520148	32470403.	28.5003087	0.0001425	0.00006250	0.6511123	4.1209448	4.1209448	
0.00000625	202.9388616	32470218.	24.4041698	0.0001525	0.00005253	0.6948904	4.4087558	4.4087558	
0.00000750	243.5251377	32470018.	21.6741372	0.0001626	0.00004256	0.7384710	4.6967249	4.6967249	
0.00000875	284.1107290	32469798.	19.7247369	0.0001726	0.00003259	0.7818536	4.9848520	4.9848520	
0.00001000	324.6955214	32469552.	18.2632317	0.0001826	0.00002263	0.8250378	5.2731372	5.2731372	
0.00001125	365.2794006	32469280.	17.1269900	0.0001927	0.00001268	0.8680233	5.5615805	5.5615805	
0.00001250	405.8622525	32468980.	16.2184327	0.0002027	0.00000273	0.9108098	5.8501819	5.8501819	
0.00001375	446.4439628	32468652.	15.4754641	0.0002128	-0.00000721	0.9533969	6.1389414	6.1389414	
0.00001500	487.0234786	32468232.	14.8566817	0.0002229	-0.00001715	0.9957838	6.4278566	6.4278566	
0.00001625	527.5950678	32467389.	14.3333961	0.0002329	-0.00002708	1.0379681	6.7169130	6.7169130	
0.00001750	568.1514929	32465800.	13.8851048	0.0002430	-0.00003701	1.0799466	7.0060907	7.0060907	
0.00001875	608.6866466	32463288.	13.4967758	0.0002531	-0.00004694	1.1217164	7.2953719	7.2953719	
0.00002000	649.1957032	32459785.	13.1571399	0.0002631	-0.00005686	1.1632751	7.5847412	7.5847412	
0.00002125	689.6749410	32455291.	12.8575838	0.0002732	-0.00006678	1.2046207	7.8741861	7.8741861	
0.00002250	730.1214756	32449843.	12.5914116	0.0002833	-0.00007669	1.2457516	8.1636961	8.1636961	
0.00002375	770.5330975	32443499.	12.3533399	0.0002934	-0.00008661	1.2866663	8.4532629	8.4532629	
0.00002500	810.9080331	32436321.	12.1391437	0.0003035	-0.00009652	1.3273639	8.7428793	8.7428793	
0.00002625	851.2449286	32428378.	11.9454048	0.0003136	-0.0001064	1.3678433	9.0325395	9.0325395	
0.00002750	851.2449286	30954361.	11.5979150	0.0003189	-0.0001211	1.3891339	9.1855373	9.1855373	C
0.00002875	881.7711027	30670299.	11.4173268	0.0003282	-0.0001318	1.4261330	9.4524963	9.4524963	C
0.00003000	915.2618004	30508727.	11.2506402	0.0003375	-0.0001425	1.4628043	9.7184570	9.7184570	C
0.00003125	948.5542753	30353737.	11.0962863	0.0003468	-0.0001532	1.4991622	9.9835095	9.9835095	C
0.00003250	981.6732552	30205331.	10.9529452	0.0003560	-0.0001640	1.5352219	10.2477509	10.2477509	C
0.00003375	1015.	30062768.	10.8193505	0.0003652	-0.0001748	1.5709794	10.5111394	10.5111394	C
0.00003500	1047.	29926174.	10.6945711	0.0003743	-0.0001857	1.6064521	10.7737898	10.7737898	C
0.00003625	1080.	29795785.	10.5778505	0.0003834	-0.0001966	1.6416633	11.0358654	11.0358654	C
0.00003750	1113.	29671537.	10.4684931	0.0003926	-0.0002074	1.6766302	11.2974864	11.2974864	C
0.00003875	1145.	29551820.	10.3655299	0.0004017	-0.0002183	1.7113156	11.5583644	11.5583644	C
0.00004000	1178.	29437570.	10.2686552	0.0004107	-0.0002293	1.7457661	11.8188402	11.8188402	C
0.00004125	1210.	29328510.	10.1773685	0.0004198	-0.0002402	1.7799906	12.0789772	12.0789772	C
0.00004250	1242.	29223374.	10.0909482	0.0004289	-0.0002511	1.8139533	12.3384937	12.3384937	C
0.00004375	1274.	29123427.	10.0093901	0.0004379	-0.0002621	1.8477234	12.5979139	12.5979139	C
0.00004500	1306.	29026678.	9.9318541	0.0004469	-0.0002731	1.8812278	12.8566697	12.8566697	C
0.00004625	1338.	28934607.	9.8584898	0.0004560	-0.0002840	1.9145498	13.1153995	13.1153995	C
0.00004750	1370.	28845622.	9.7886067	0.0004650	-0.0002950	1.9476260	13.3736058	13.3736058	C

0.00004875	1402.	28760424.	9.7222096	0.0004740	-0.0003060	1.9805064	13.6316740	13.6316740	C
0.00005125	1466.	28599497.	9.5985816	0.0004919	-0.0003281	2.0456301	14.1469920	14.1469920	C
0.00005375	1529.	28450633.	9.4860128	0.0005099	-0.0003501	2.1099585	14.6616225	14.6616225	C
0.00005625	1593.	28312206.	9.3829983	0.0005278	-0.0003722	2.1734881	15.1755161	15.1755161	C
0.00005875	1656.	28182925.	9.2882857	0.0005457	-0.0003943	2.2362154	15.6886169	15.6886169	C
0.00006125	1719.	28062836.	9.2012760	0.0005636	-0.0004164	2.2982326	16.2016666	16.2016666	C
0.00006375	1782.	27949536.	9.1205330	0.0005814	-0.0004386	2.3594236	16.7136855	16.7136855	C
0.00006625	1845.	27843986.	9.0460190	0.0005993	-0.0004607	2.4199443	17.2259642	17.2259642	C
0.00006875	1907.	27744086.	8.9765219	0.0006171	-0.0004829	2.4796702	17.7374408	17.7374408	C
0.00007125	1970.	27650365.	8.9119888	0.0006350	-0.0005050	2.5387173	18.2490971	18.2490971	C
0.00007375	2033.	27561798.	8.8517266	0.0006528	-0.0005272	2.5970392	18.7605306	18.7605306	C
0.00007625	2095.	27477831.	8.7952921	0.0006706	-0.0005494	2.6546312	19.2716900	19.2716900	C
0.00007875	2158.	27398544.	8.7425633	0.0006885	-0.0005715	2.7115555	19.7831292	19.7831292	C
0.00008125	2220.	27323076.	8.6929762	0.0007063	-0.0005937	2.7677540	20.2943253	20.2943253	C
0.00008375	2282.	27251162.	8.6462892	0.0007241	-0.0006159	2.8232380	20.8053750	20.8053750	C
0.00008625	2345.	27182822.	8.6024210	0.0007420	-0.0006380	2.8780537	21.3167057	21.3167057	C
0.00008875	2407.	27117752.	8.5611337	0.0007598	-0.0006602	2.9322000	21.8283182	21.8283182	C
0.00009125	2469.	27055148.	8.5219030	0.0007776	-0.0006824	2.9855900	22.3393861	22.3393861	C
0.00009375	2531.	26995319.	8.4848597	0.0007955	-0.0007045	3.0383082	22.8507125	22.8507125	C
0.00009625	2593.	26938063.	8.4498422	0.0008133	-0.0007267	3.0903560	23.3623224	23.3623224	C
0.00009875	2655.	26883181.	8.4166970	0.0008311	-0.0007489	3.1417323	23.8742164	23.8742164	C
0.0001013	2717.	26830317.	8.3851638	0.0008490	-0.0007710	3.1924010	24.3860376	24.3860376	C
0.0001038	2778.	26779305.	8.3551138	0.0008668	-0.0007932	3.2423586	24.8977490	24.8977490	C
0.0001063	2840.	26730206.	8.3265709	0.0008847	-0.0008153	3.2916435	25.4097468	25.4097468	C
0.0001088	2902.	26682886.	8.2994314	0.0009026	-0.0008374	3.3402547	25.9220319	25.9220319	C
0.0001113	2963.	26637225.	8.2736009	0.0009204	-0.0008596	3.3881910	26.4346052	26.4346052	C
0.0001138	3025.	26593112.	8.2489934	0.0009383	-0.0008817	3.4354512	26.9474673	26.9474673	C
0.0001163	3086.	26550292.	8.2254095	0.0009562	-0.0009038	3.4819977	27.4602120	27.4602120	C
0.0001188	3148.	26508744.	8.2028312	0.0009741	-0.0009259	3.5278452	27.9730004	27.9730004	C
0.0001213	3209.	26468478.	8.1812670	0.0009920	-0.0009480	3.5730151	28.4860806	28.4860806	C
0.0001238	3271.	26429414.	8.1606557	0.0010099	-0.0009701	3.6175064	28.9994534	28.9994534	C
0.0001263	3332.	26391480.	8.1409408	0.0010278	-0.0009922	3.6613180	29.5131198	29.5131198	C
0.0001288	3393.	26354609.	8.1220704	0.0010457	-0.0010143	3.7044486	30.0270806	30.0270806	C
0.0001313	3454.	26318739.	8.1039964	0.0010636	-0.0010364	3.7468971	30.5413367	30.5413367	C
0.0001338	3515.	26283813.	8.0866745	0.0010816	-0.0010584	3.7886624	31.0558890	31.0558890	C
0.0001363	3577.	26249691.	8.0699793	0.0010995	-0.0010805	3.8297172	31.5704063	31.5704063	C
0.0001388	3638.	26216359.	8.0539058	0.0011175	-0.0011025	3.8700703	32.0850037	32.0850037	C
0.0001413	3698.	26183830.	8.0384743	0.0011354	-0.0011246	3.9097384	32.5999009	32.5999009	C
0.0001438	3759.	26152061.	8.0236518	0.0011534	-0.0011466	3.9487203	33.1150987	33.1150987	C
0.0001463	3820.	26121011.	8.0094071	0.0011714	-0.0011686	3.9870146	33.6305981	33.6305981	C
0.0001488	3881.	26090644.	7.9957113	0.0011894	-0.0011906	4.0246204	-34.1834000	-34.1834000	C
0.0001588	4124.	25975337.	7.9459032	0.0012614	-0.0012786	4.1681336	-36.7107478	-36.7107478	C
0.0001688	4365.	25868416.	7.9028560	0.0013336	-0.0013664	4.3004891	-39.2338981	-39.2338981	C
0.0001788	4606.	25768386.	7.8653924	0.0014059	-0.0014541	4.4216050	-41.7530714	-41.7530714	C

0.0001888	4846.	25674249.	7.8328245	0.0014784	-0.0015416	4.5314697	-44.2671765	-44.2671765	C
0.0001988	5085.	25585063.	7.8044248	0.0015511	-0.0016289	4.6300018	-46.7761462	-46.7761462	C
0.0002088	5323.	25500066.	7.7796057	0.0016240	-0.0017160	4.7171179	-49.2799116	-49.2799116	C
0.0002188	5551.	25375430.	7.7532043	0.0016960	-0.0018040	4.7917431	-51.8081098	-50.0000000	CY
0.0002288	5742.	25099514.	7.7137220	0.0017645	-0.0018955	4.8521064	-54.4383963	50.0000000	CY
0.0002388	5896.	24694525.	7.6727721	0.0018319	-0.0019881	4.9014066	-57.1017434	50.0000000	CY
0.0002488	6021.	24205988.	7.6373432	0.0018998	-0.0020802	4.9410314	-59.7490150	50.0000000	CY
0.0002588	6126.	23676682.	7.6061196	0.0019681	-0.0021719	4.9706663	-60.0000000	50.0000000	CY
0.0002688	6218.	23134961.	7.5770846	0.0020363	-0.0022637	4.9900509	-60.0000000	50.0000000	CY
0.0002788	6297.	22590712.	7.5498276	0.0021045	-0.0023555	4.9991985	60.0000000	50.0000000	CY
0.0002888	6368.	22052491.	7.5250280	0.0021729	-0.0024471	4.9999677	60.0000000	50.0000000	CY
0.0002988	6430.	21524463.	7.5017893	0.0022412	-0.0025388	4.9986185	60.0000000	50.0000000	CY
0.0003088	6487.	21010616.	7.4803817	0.0023096	-0.0026304	4.9994732	60.0000000	50.0000000	CY
0.0003188	6538.	20511344.	7.4605536	0.0023781	-0.0027219	4.9998548	60.0000000	50.0000000	CY
0.0003288	6584.	20027151.	7.4421278	0.0024466	-0.0028134	4.9999800	60.0000000	50.0000000	CY
0.0003388	6626.	19559111.	7.4249269	0.0025152	-0.0029048	4.9999999	60.0000000	50.0000000	CY
0.0003488	6664.	19106927.	7.4091688	0.0025839	-0.0029961	4.9996751	60.0000000	50.0000000	CY
0.0003588	6698.	18670412.	7.3948236	0.0026529	-0.0030871	4.9999980	60.0000000	50.0000000	CY
0.0003688	6730.	18249855.	7.3816067	0.0027220	-0.0031780	4.9999533	60.0000000	50.0000000	CY
0.0003788	6759.	17844961.	7.3693882	0.0027912	-0.0032688	4.9997584	60.0000000	50.0000000	CY
0.0003888	6785.	17453779.	7.3581971	0.0028605	-0.0033595	4.9992449	60.0000000	50.0000000	CY
0.0003988	6809.	17077096.	7.3479944	0.0029300	-0.0034500	4.9981830	60.0000000	50.0000000	CY
0.0004088	6832.	16714976.	7.3385096	0.0029996	-0.0035404	4.9965403	60.0000000	50.0000000	CY
0.0004188	6853.	16365276.	7.3303725	0.0030696	-0.0036304	4.9998683	60.0000000	50.0000000	CY
0.0004288	6872.	16028209.	7.3224222	0.0031395	-0.0037205	4.9987959	60.0000000	50.0000000	CY
0.0004388	6890.	15703333.	7.3155942	0.0032097	-0.0038103	4.9962833	60.0000000	50.0000000	CY
0.0004488	6906.	15390205.	7.3092286	0.0032800	-0.0039000	4.9997921	60.0000000	50.0000000	CY
0.0004588	6921.	15087670.	7.3035906	0.0033505	-0.0039895	4.9979317	60.0000000	50.0000000	CY
0.0004688	6936.	14796423.	7.2984876	0.0034212	-0.0040788	4.9999999	60.0000000	50.0000000	CY
0.0004788	6949.	14514281.	7.2939910	0.0034920	-0.0041680	4.9986991	60.0000000	50.0000000	CY
0.0004888	6961.	14242845.	7.2898596	0.0035629	-0.0042571	4.9967607	60.0000000	50.0000000	CY
0.0004988	6972.	13979418.	7.2864556	0.0036341	-0.0043459	4.9989269	60.0000000	50.0000000	CY
0.0005088	6983.	13725603.	7.2833098	0.0037054	-0.0044346	4.9959337	60.0000000	50.0000000	CY
0.0005188	6993.	13479770.	7.2807035	0.0037769	-0.0045231	4.9987346	60.0000000	50.0000000	CY
0.0005288	7002.	13241905.	7.2783882	0.0038484	-0.0046116	4.9976792	60.0000000	50.0000000	CY

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   Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1
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Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.
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Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	166.100	6832.360	0.00300000

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	6832.	107.965000	4441.	25836954.
1	0.70	6832.	116.270000	4783.	25699111.
1	0.75	6832.	124.575000	5124.	25571056.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	7.8000	0.00	N.A.	No	0.00	3243072.
2	62.0000	54.2000	No	No	3243072.	0.00
3	69.0000	61.2000	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Displacement and Moment (Loading Type 4)

```
Displacement of pile head                        =     0.740000 inches
Moment at pile head                              =          0.0 in-lbs
Axial load at pile head                          =     166100.0 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7400	0.00	5830.	-0.00485	0.00	3.25E+10	0.00	0.00	0.00
0.6000	0.7051	47777.	5830.	-0.00484	0.00	3.25E+10	0.00	0.00	0.00
1.2000	0.6703	95541.	5830.	-0.00483	0.00	3.25E+10	0.00	0.00	0.00
1.8000	0.6356	143280.	5830.	-0.00480	0.00	3.25E+10	0.00	0.00	0.00
2.4000	0.6011	190981.	5830.	-0.00476	0.00	3.25E+10	0.00	0.00	0.00
3.0000	0.5670	238632.	5830.	-0.00472	0.00	3.25E+10	0.00	0.00	0.00
3.6000	0.5332	286219.	5830.	-0.00466	0.00	3.25E+10	0.00	0.00	0.00
4.2000	0.4999	333730.	5830.	-0.00459	0.00	3.25E+10	0.00	0.00	0.00
4.8000	0.4671	381152.	5830.	-0.00451	0.00	3.25E+10	0.00	0.00	0.00
5.4000	0.4350	428474.	5830.	-0.00442	0.00	3.25E+10	0.00	0.00	0.00
6.0000	0.4035	475682.	5830.	-0.00432	0.00	3.25E+10	0.00	0.00	0.00
6.6000	0.3728	522764.	5830.	-0.00421	0.00	3.25E+10	0.00	0.00	0.00
7.2000	0.3429	569707.	5830.	-0.00409	0.00	3.25E+10	0.00	0.00	0.00
7.8000	0.3139	616499.	5830.	-0.00396	0.00	3.25E+10	0.00	1.15E-12	0.00
8.4000	0.2859	663127.	5726.	-0.00381	0.00	3.25E+10	-28.9756	729.6408	0.00
9.0000	0.2590	708078.	5425.	-0.00366	0.00	3.25E+10	-54.7624	1522.	0.00
9.6000	0.2332	750001.	4936.	-0.00350	0.00	3.24E+10	-81.0469	2502.	0.00
10.2000	0.2086	787525.	4275.	-0.00333	0.00	3.24E+10	-102.6017	3542.	0.00
10.8000	0.1852	819520.	3480.	-0.00315	0.00	3.24E+10	-118.0226	4587.	0.00
11.4000	0.1632	845179.	2600.	-0.00297	0.00	3.24E+10	-126.4755	5580.	0.00

12.0000	0.1425	864058.	1680.	-0.00277	0.00	3.08E+10	-129.2299	6528.	0.00
12.6000	0.1233	875996.	753.0005	-0.00257	0.00	3.07E+10	-128.1635	7484.	0.00
13.2000	0.1055	881045.	-137.2230	-0.00236	0.00	3.07E+10	-119.1208	8127.	0.00
13.8000	0.08927	879670.	-1014.	-0.00216	0.00	3.07E+10	-124.3251	10027.	0.00
14.4000	0.07449	871605.	-1913.	-0.00195	0.00	3.08E+10	-125.4487	12125.	0.00
15.0000	0.06118	856791.	-2830.	-0.00175	0.00	3.09E+10	-129.3498	15221.	0.00
15.6000	0.04931	835034.	-3768.	-0.00156	0.00	3.24E+10	-131.1689	19152.	0.00
16.2000	0.03877	806255.	-4707.	-0.00137	0.00	3.24E+10	-129.7400	24091.	0.00
16.8000	0.02953	770537.	-5623.	-0.00120	0.00	3.24E+10	-124.7641	30425.	0.00
17.4000	0.02151	728146.	-6490.	-0.00103	0.00	3.25E+10	-115.9049	38801.	0.00
18.0000	0.01465	679553.	-7227.	-8.77E-04	0.00	3.25E+10	-88.7769	43623.	0.00
18.6000	0.00888	626178.	-7751.	-7.32E-04	0.00	3.25E+10	-56.9871	46189.	0.00
19.2000	0.00411	569683.	-8057.	-5.99E-04	0.00	3.25E+10	-27.8564	48756.	0.00
19.8000	2.54E-04	511592.	-8164.	-4.79E-04	0.00	3.25E+10	-1.8100	51322.	0.00
20.4000	-0.00279	453272.	-8095.	-3.72E-04	0.00	3.25E+10	20.8741	53888.	0.00
21.0000	-0.00511	395914.	-7876.	-2.78E-04	0.00	3.25E+10	40.0528	56454.	0.00
21.6000	-0.00680	340527.	-7531.	-1.97E-04	0.00	3.25E+10	55.7031	59020.	0.00
22.2000	-0.00794	287938.	-7086.	-1.27E-04	0.00	3.25E+10	67.9055	61586.	0.00
22.8000	-0.00862	238792.	-6565.	-6.85E-05	0.00	3.25E+10	76.8270	64152.	0.00
23.4000	-0.00893	193566.	-5991.	-2.06E-05	0.00	3.25E+10	82.7031	66718.	0.00
24.0000	-0.00892	152576.	-5384.	1.78E-05	0.00	3.25E+10	85.8210	69284.	0.00
24.6000	-0.00867	115994.	-4764.	4.76E-05	0.00	3.25E+10	86.5034	71850.	0.00
25.2000	-0.00823	83866.	-4146.	6.98E-05	0.00	3.25E+10	85.0935	74416.	0.00
25.8000	-0.00766	56127.	-3545.	8.53E-05	0.00	3.25E+10	81.9418	76982.	0.00
26.4000	-0.00701	32620.	-2971.	9.51E-05	0.00	3.25E+10	77.3943	79548.	0.00
27.0000	-0.00629	13118.	-2434.	1.00E-04	0.00	3.25E+10	71.7832	82115.	0.00
27.6000	-0.00556	-2667.	-1940.	1.01E-04	0.00	3.25E+10	65.4191	84681.	0.00
28.2000	-0.00483	-15060.	-1494.	9.94E-05	0.00	3.25E+10	58.5850	87247.	0.00
28.8000	-0.00413	-24412.	-1097.	9.50E-05	0.00	3.25E+10	51.5322	89813.	0.00
29.4000	-0.00347	-31086.	-751.4867	8.89E-05	0.00	3.25E+10	44.4779	92379.	0.00
30.0000	-0.00285	-35446.	-455.9907	8.15E-05	0.00	3.25E+10	37.6043	94945.	0.00
30.6000	-0.00229	-37847.	-208.8032	7.34E-05	0.00	3.25E+10	31.0589	97511.	0.00
31.2000	-0.00180	-38628.	-7.1524	6.49E-05	0.00	3.25E+10	24.9552	100077.	0.00
31.8000	-0.00136	-38105.	152.4396	5.64E-05	0.00	3.25E+10	19.3759	102643.	0.00
32.4000	-9.84E-04	-36568.	273.9407	4.81E-05	0.00	3.25E+10	14.3745	105209.	0.00
33.0000	-6.67E-04	-34276.	361.6143	4.02E-05	0.00	3.25E+10	9.9793	107775.	0.00
33.6000	-4.04E-04	-31457.	419.8484	3.29E-05	0.00	3.25E+10	6.1968	110341.	0.00
34.2000	-1.92E-04	-28309.	453.0104	2.63E-05	0.00	3.25E+10	3.0148	112908.	0.00
34.8000	-2.53E-05	-24996.	465.3273	2.04E-05	0.00	3.25E+10	0.4065	115474.	0.00
35.4000	1.02E-04	-21657.	460.7912	1.52E-05	0.00	3.25E+10	-1.6665	118040.	0.00
36.0000	1.94E-04	-18397.	443.0882	1.08E-05	0.00	3.25E+10	-3.2510	120606.	0.00
36.6000	2.57E-04	-15302.	415.5490	7.06E-06	0.00	3.25E+10	-4.3988	123172.	0.00
37.2000	2.96E-04	-12430.	381.1192	3.99E-06	0.00	3.25E+10	-5.1650	125738.	0.00
37.8000	3.15E-04	-9823.	342.3471	1.52E-06	0.00	3.25E+10	-5.6051	128304.	0.00

38.4000	3.18E-04	-7504.	301.3844	-4.02E-07	0.00	3.25E+10	-5.7734	130870.	0.00
39.0000	3.09E-04	-5483.	260.0007	-1.84E-06	0.00	3.25E+10	-5.7220	133436.	0.00
39.6000	2.91E-04	-3756.	219.6054	-2.87E-06	0.00	3.25E+10	-5.4989	136002.	0.00
40.2000	2.67E-04	-2313.	181.2770	-3.54E-06	0.00	3.25E+10	-5.1479	138568.	0.00
40.8000	2.40E-04	-1137.	145.7975	-3.92E-06	0.00	3.25E+10	-4.7075	141134.	0.00
41.4000	2.11E-04	-204.4694	113.6889	-4.07E-06	0.00	3.25E+10	-4.2115	143700.	0.00
42.0000	1.82E-04	509.8219	85.2501	-4.04E-06	0.00	3.25E+10	-3.6881	146267.	0.00
42.6000	1.53E-04	1033.	60.5951	-3.87E-06	0.00	3.25E+10	-3.1605	148833.	0.00
43.2000	1.26E-04	1392.	39.6874	-3.60E-06	0.00	3.25E+10	-2.6472	151399.	0.00
43.8000	1.01E-04	1613.	22.3741	-3.26E-06	0.00	3.25E+10	-2.1621	153965.	0.00
44.4000	7.89E-05	1722.	8.4155	-2.89E-06	0.00	3.25E+10	-1.7153	156531.	0.00
45.0000	5.94E-05	1741.	-2.4879	-2.51E-06	0.00	3.25E+10	-1.3134	159097.	0.00
45.6000	4.28E-05	1692.	-10.6726	-2.13E-06	0.00	3.25E+10	-0.9601	161663.	0.00
46.2000	2.88E-05	1592.	-16.4923	-1.76E-06	0.00	3.25E+10	-0.6565	164229.	0.00
46.8000	1.73E-05	1459.	-20.3021	-1.43E-06	0.00	3.25E+10	-0.4018	166795.	0.00
47.4000	8.24E-06	1303.	-22.4460	-1.12E-06	0.00	3.25E+10	-0.1937	169361.	0.00
48.0000	1.21E-06	1138.	-23.2473	-8.50E-07	0.00	3.25E+10	-0.02886	171927.	0.00
48.6000	-4.00E-06	970.7319	-23.0021	-6.16E-07	0.00	3.25E+10	0.09698	174493.	0.00
49.2000	-7.66E-06	808.2386	-21.9746	-4.19E-07	0.00	3.25E+10	0.1884	177060.	0.00
49.8000	-1.00E-05	655.2992	-20.3952	-2.57E-07	0.00	3.25E+10	0.2503	179626.	0.00
50.4000	-1.14E-05	515.1614	-18.3446	-1.27E-07	0.00	3.25E+10	0.3193	202435.	0.00
51.0000	-1.19E-05	391.4402	-15.9779	-2.63E-08	0.00	3.25E+10	0.3381	205286.	0.00
51.6000	-1.17E-05	285.1431	-13.5393	4.87E-08	0.00	3.25E+10	0.3393	208138.	0.00
52.2000	-1.12E-05	196.3572	-11.1410	1.02E-07	0.00	3.25E+10	0.3269	210989.	0.00
52.8000	-1.03E-05	124.4682	-8.8664	1.38E-07	0.00	3.25E+10	0.3049	213840.	0.00
53.4000	-9.17E-06	68.3511	-6.7749	1.59E-07	0.00	3.25E+10	0.2761	216691.	0.00
54.0000	-7.97E-06	26.5299	-4.9054	1.70E-07	0.00	3.25E+10	0.2432	219542.	0.00
54.6000	-6.73E-06	-2.6923	-3.2813	1.72E-07	0.00	3.25E+10	0.2080	222394.	0.00
55.2000	-5.50E-06	-21.1330	-1.9138	1.70E-07	0.00	3.25E+10	0.1719	225245.	0.00
55.8000	-4.29E-06	-30.6564	-0.8055	1.64E-07	0.00	3.25E+10	0.1359	228096.	0.00
56.4000	-3.14E-06	-33.1245	0.04597	1.57E-07	0.00	3.25E+10	0.1006	230947.	0.00
57.0000	-2.03E-06	-30.3694	0.6458	1.50E-07	0.00	3.25E+10	0.06604	233798.	0.00
57.6000	-9.80E-07	-24.1828	0.9995	1.44E-07	0.00	3.25E+10	0.03221	236650.	0.00
58.2000	3.51E-08	-16.3200	1.1113	1.39E-07	0.00	3.25E+10	-0.00117	239501.	0.00
58.8000	1.02E-06	-8.5135	0.9829	1.36E-07	0.00	3.25E+10	-0.03447	242352.	0.00
59.4000	2.00E-06	-2.4919	0.6137	1.35E-07	0.00	3.25E+10	-0.06810	245203.	0.00
60.0000	2.97E-06	0.00	0.00	1.35E-07	0.00	3.25E+10	-0.1024	124027.	0.00

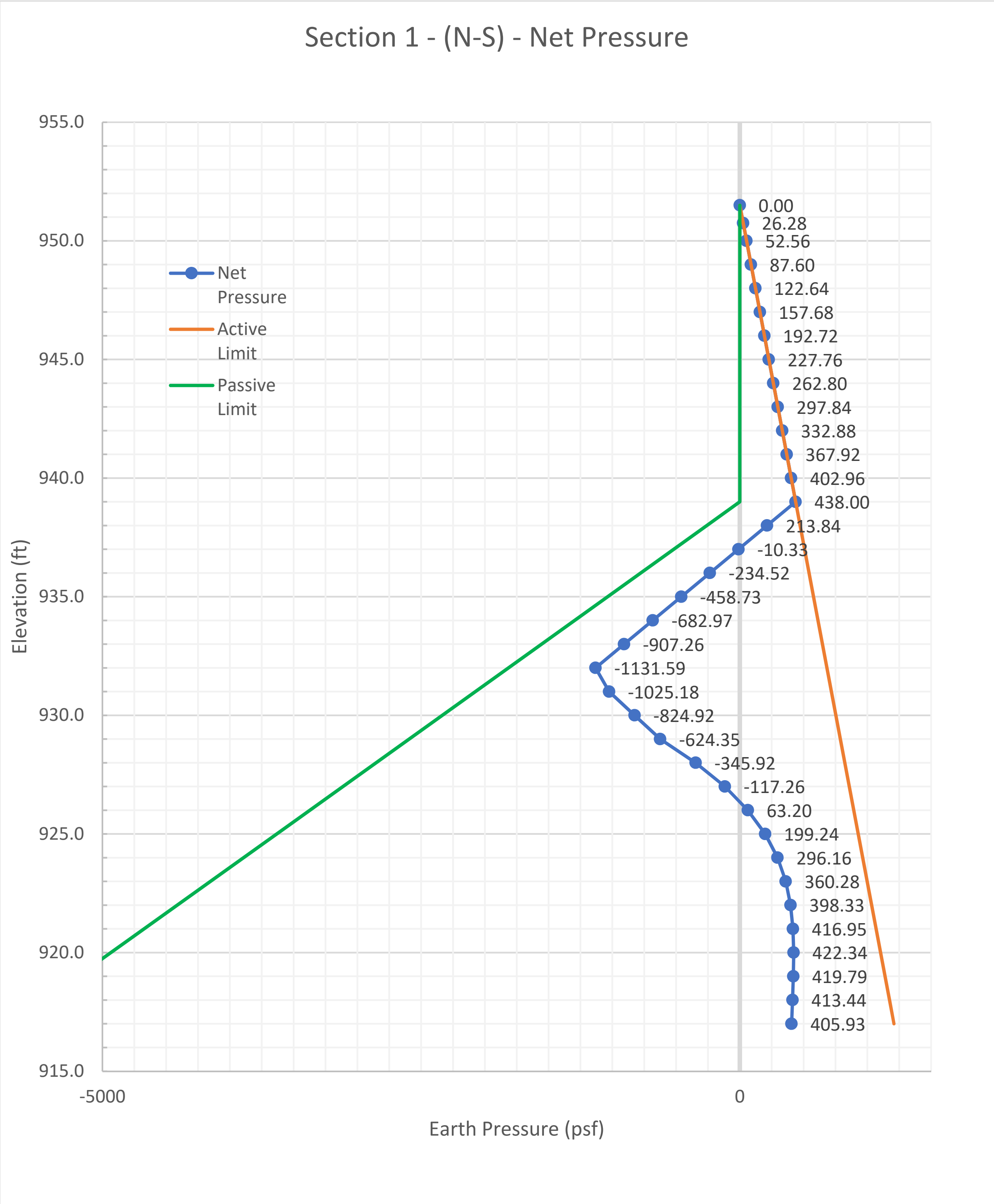
* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

```
Output Summary for Load Case No. 1:

Pile-head deflection              =     0.74000000 inches
Computed slope at pile head       =    -0.00484813 radians
Maximum bending moment            =        881045. inch-lbs
Maximum shear force               =         -8164. lbs
Depth of maximum bending moment   =    13.20000000 feet below pile head
Depth of maximum shear force      =    19.80000000 feet below pile head
Number of iterations              =             12
Number of zero deflection points  =              4


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                  Axial    Pile-head  Pile-head  Max Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs      in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
  1  y, in     0.7400  M, in-lb        0.00    166100.     0.7400   -0.00485     -8164.    881045.


Maximum pile-head deflection = 0.7400000000 inches
Maximum pile-head rotation   = -0.0048481299 radians = -0.277777 deg.

The analysis ended normally.
```

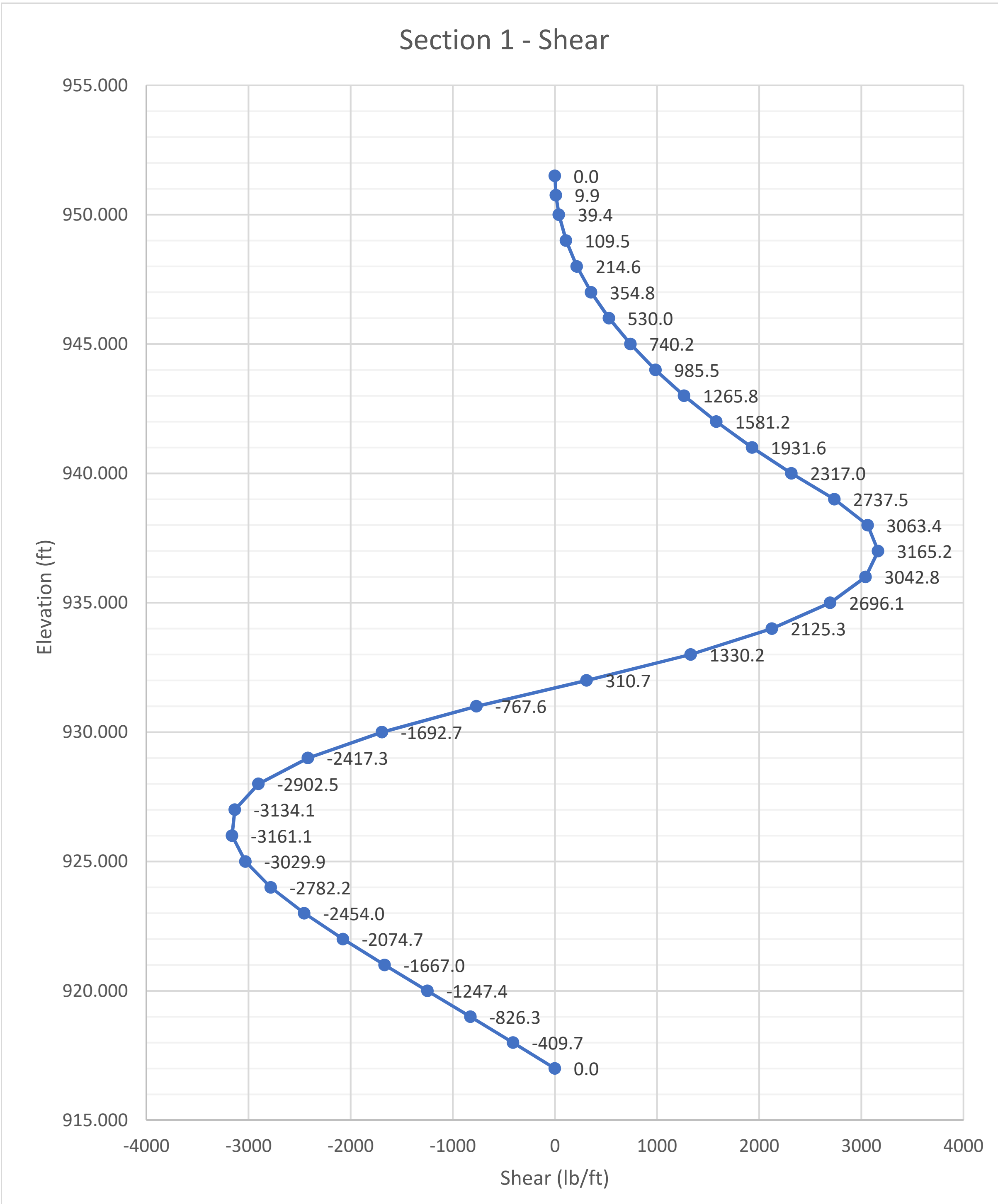
Appendix D

Sheet Pile Analysis Results

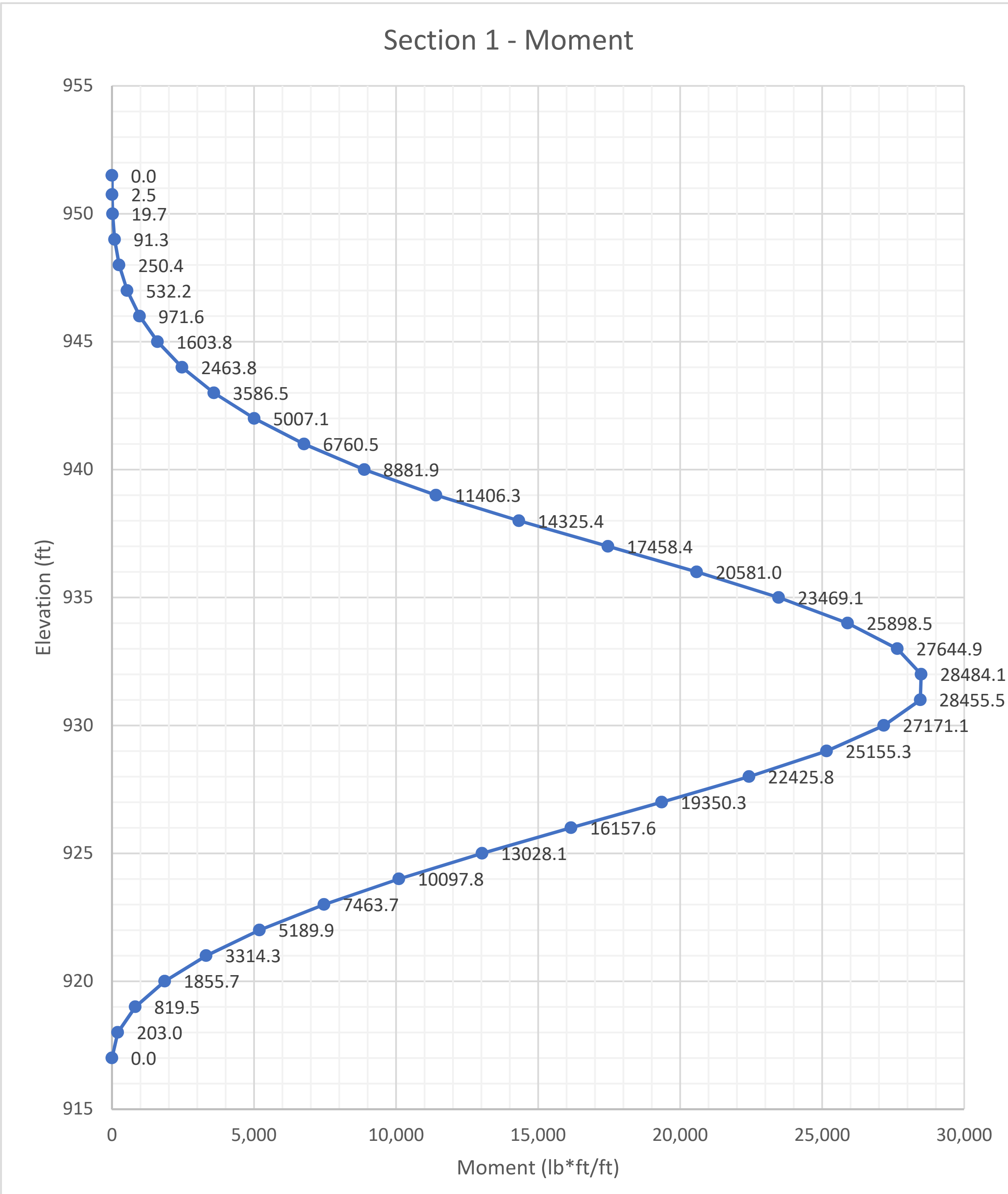
GEI Consultants	Client	HDR			Page	D1
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/20	Date	3/31/20	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 1 (Parallel to Centerline of Rail)					



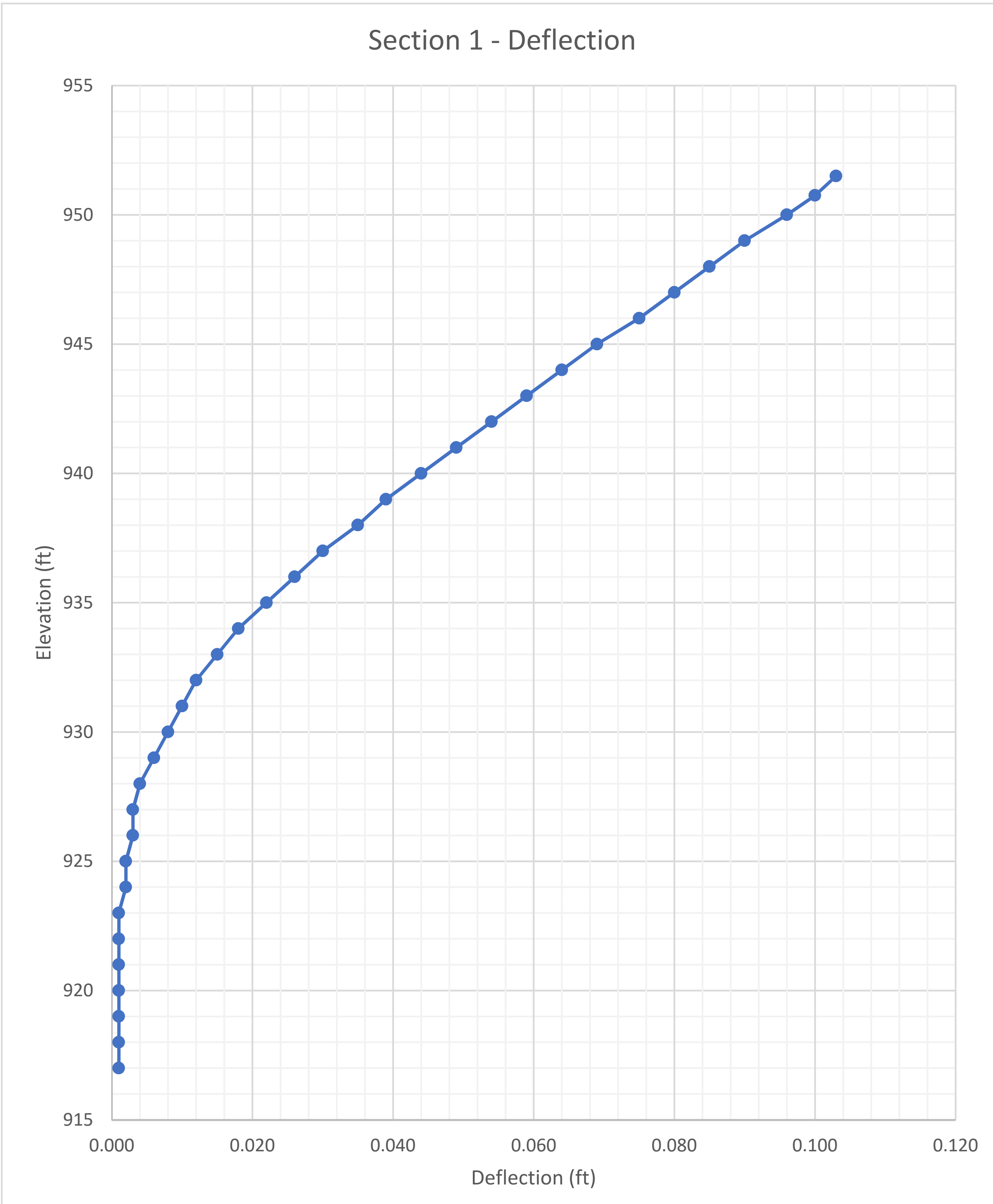
	Client	HDR			Page	D2
GEI Consultants	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/20	Date	3/31/20	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 1 (Parallel to Centerline of Rail)					



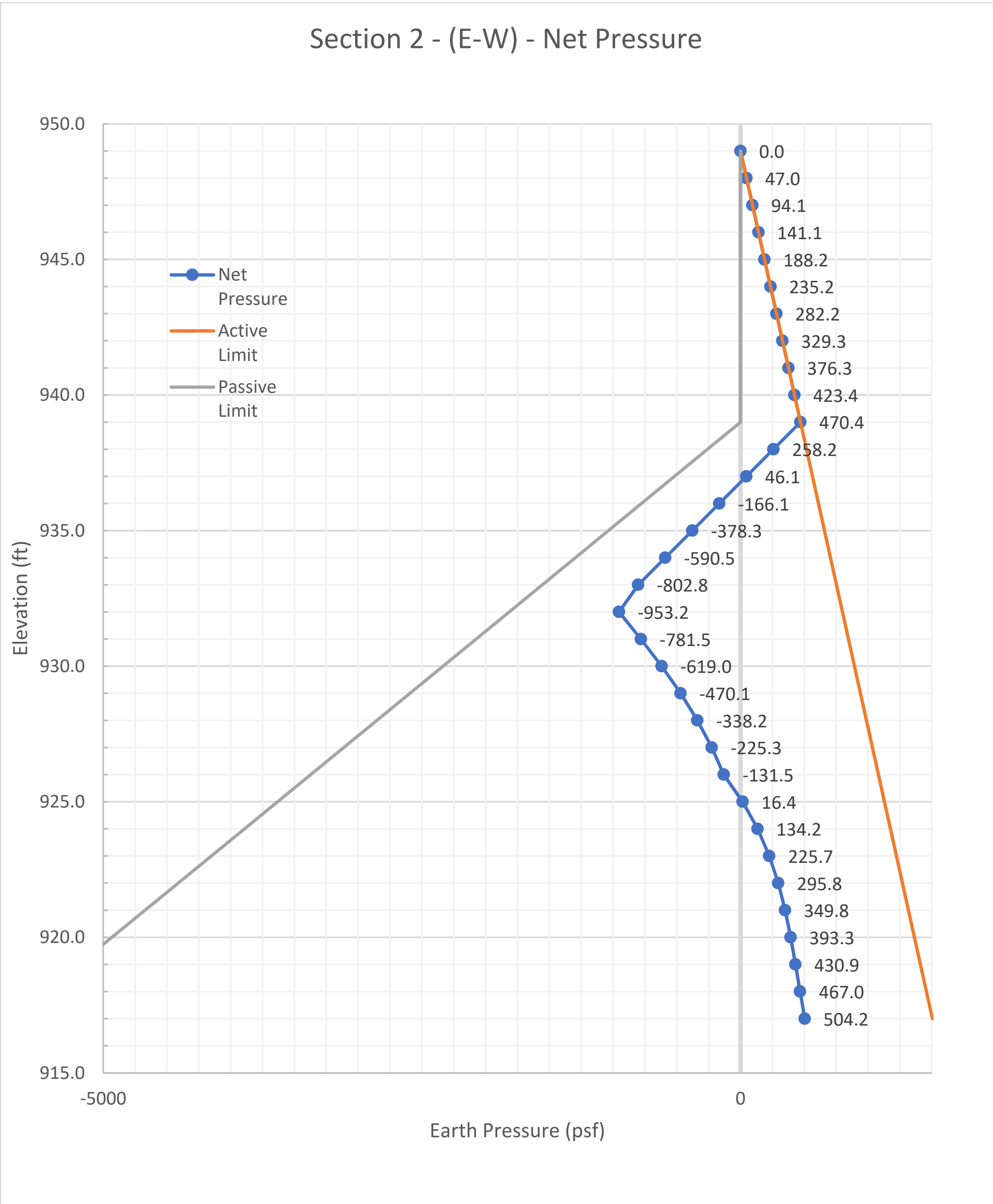
GEI Consultants	**Client**	HDR			**Page**	D3
	Project	MassDOT RR Bridge 79.90			**Pg. Rev.**	
	By	J. Christensen	**Chk.**	M. Flynn	**App.**	
	Date	3/30/20	**Date**	3/31/20	**Date**	
Project No.	1703257	**Document No.**	N/A			
Subject	Results of Sheet Pile Analysis - Section 1 (Parallel to Centerline of Rail)					



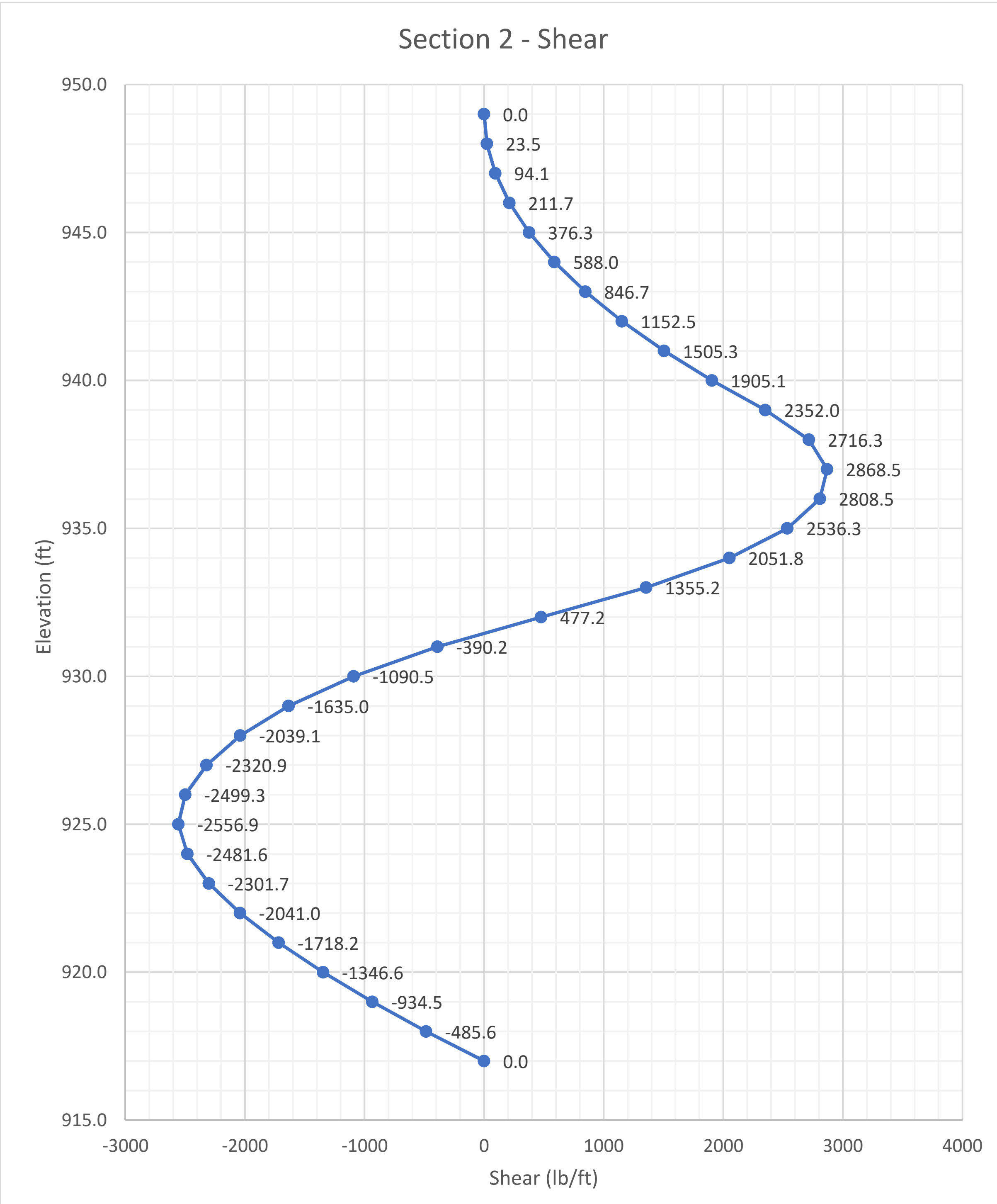
GEI Consultants	Client	HDR			Page	D4
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/20	Date	3/31/20	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 1 (Parallel to Centerline of Rail)					



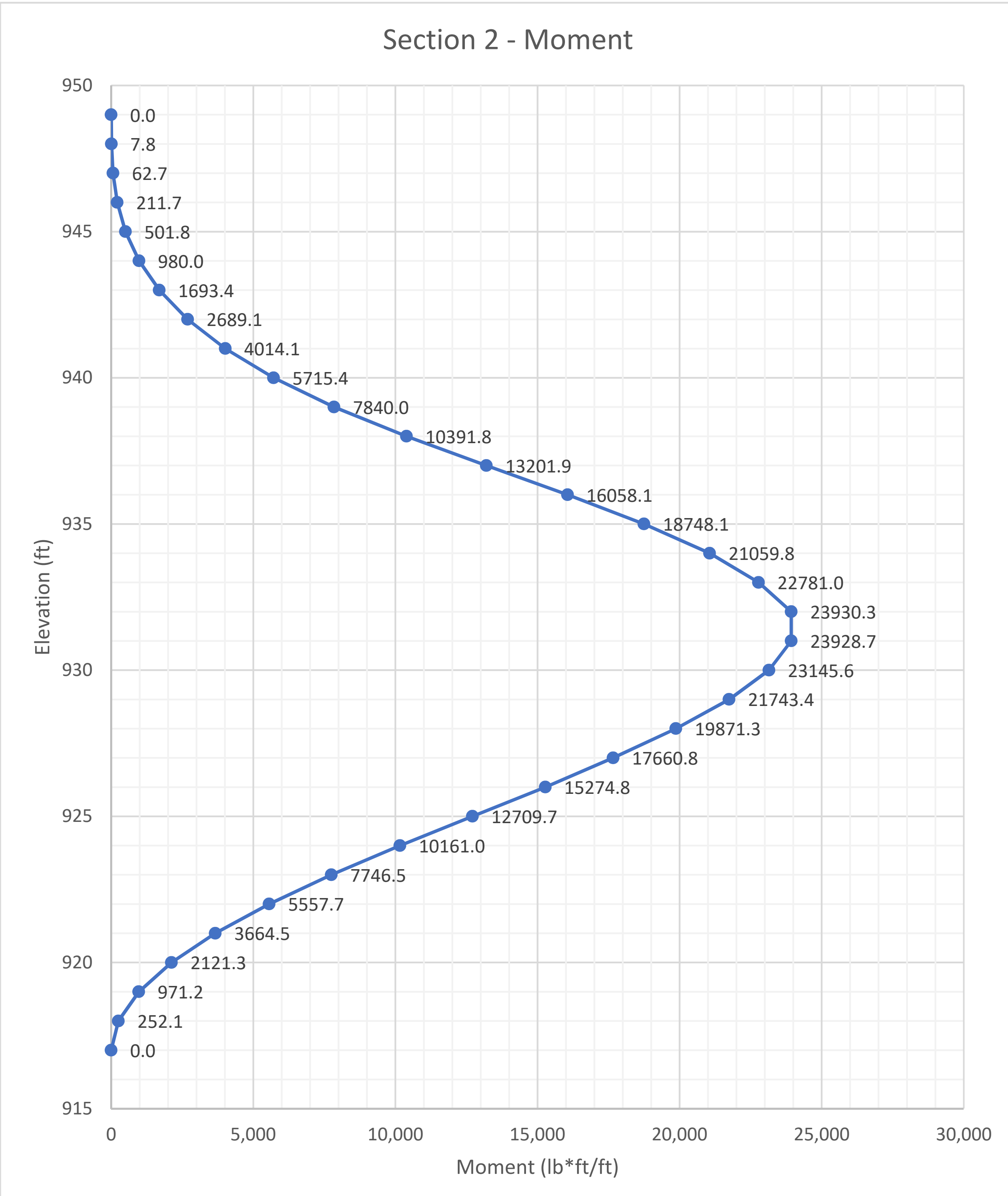
GEI Consultants	Client	HDR			Page	D5
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/2020	Date	3/31/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 2 (Perpendicular to Centerline of Rail)					



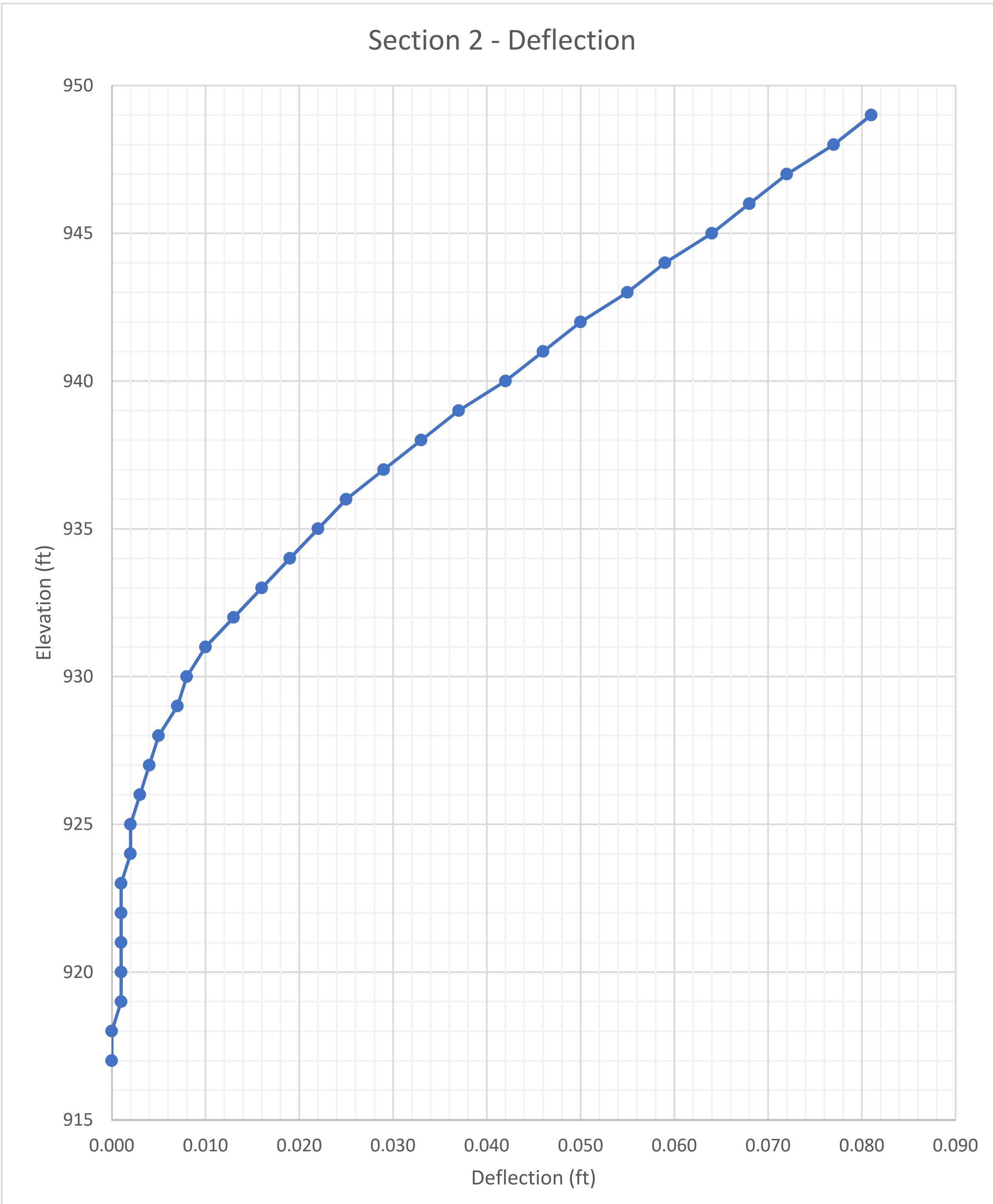
GEI Consultants	Client	HDR			Page	D6
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/2020	Date	3/31/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 2 (Perpendicular to Centerline of Rail)					



GEI Consultants	Client	HDR			Page	D7
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/2020	Date	3/31/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 2 (Perpendicular to Centerline of Rail)					



GEI Consultants	Client	HDR			Page	D8
	Project	MassDOT RR Bridge 79.90			Pg. Rev.	
	By	J. Christensen	Chk.	M. Flynn	App.	
	Date	3/30/2020	Date	3/31/2020	Date	
Project No.	1703257	Document No.	N/A			
Subject	Results of Sheet Pile Analysis - Section 2 (Perpendicular to Centerline of Rail)					



GEI Consultants

Consulting Engineers and Scientists

October 24, 2022
Project 1703257

Via email: June.Wu@hdrinc.com

Ms. June Wu, P.E.
HDR Engineering, Inc.
99 High Street, Suite 2300
Boston, MA 02110

Dear Ms. Wu:

Re: Addendum 1 to Geotechnical Recommendations for Bridge Replacement
Berkshire Line Bridge - Mile Post 79.90
Lenox, Massachusetts

This addendum to our March 31, 2020 Geotechnical Recommendations for Bridge Replacement, Berkshire Line Bridge – Mile Post 79.90, Lenox, Massachusetts, presents the results of updated geotechnical analyses for the proposed sheet piles.

Steel sheet piles are proposed in front of the north and south abutments and along the east and west sides of the embankments to retain the embankment fill behind the abutments. We updated our analyses based on changes to the proposed sheet pile design. The proposed sheet piles along the east and west sides of the embankments were moved closer to the tracks. As a result, the height of the sheet piles increased, and the soil and railroad surcharge loads on the sheet piles increased. Wales and tie rods were added to the sheet piles due to the increased loading. The results of our updated sheet pile analyses are provided in Appendix A.

If you have any questions, please feel free to contact James Christensen at 781-721-4126 or Darren Clark at 207-797-8910.

Sincerely,

GEI CONSULTANTS, INC.

James L. Christensen, P.E.
Project Manager

Darren D. Clark, P.E. (ME)
Project Manager

JLC/DDC:bdp
Attachments: Appendix A – Updated Sheet Pile Analysis Results

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Appendix A

Updated Sheet Pile Analysis Results

GEI Consultants	Client	HDR Engineering, Inc.			Page	
	Project	MassDOT Berkshire Line Bridges			Pg. Rev.	
	By	J. Christensen	Chk.	C. Hoplin	App.	
	Date	07/06/2022	Date	07/06/2022	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90					

Purpose

Perform geotechnical analyses for proposed sheet piles at MassDOT's Berkshire Line Bridge 79.90.

Methodology

Use computer program WALLAP to analyze the proposed sheet pile wall. WALLAP is a beam on elastic foundation program that is used to model staged construction and estimate brace loads, moment and shear loads of the wall elements, and wall movements in the support of excavation wall. The program considers a beam (the sheet pile wall) with soil springs on both sides of the wall to account for active and passive soil pressures. The soil springs start at at-rest pressure and then vary linearly with wall displacement up until plastic yield at the active and passive limits.

Soil Properties

The soil properties selected for the analyses are based on the borings performed on the site. For the purpose of this analysis, both the embankment fill and underlying soils used the same soil properties.

Layer	Unit Weight (pcf)	Linearly Increasing Modulus with depth, dE/dy (psf/ft)	Active Earth Pressure Coefficient, K_a	Active Earth Pressure Coefficient, K_a	Passive Earth Pressure Coefficient, K_p
Fill/Silt+Sand	125	40,000	0.5	0.292	4.0

Groundwater Conditions

The groundwater was assumed to be at El. 947. Since higher water levels will be less conservative, we included a stage with the groundwater drawn down to the scour level at El. 940.98.

Staging

The staging of the surcharge applications, brace installations, excavation (scour), and water level changes are provided in the WALLAP output.

GEI Consultants	Client	HDR Engineering, Inc.			Page	
	Project	MassDOT Berkshire Line Bridges			Pg. Rev.	
	By	J. Christensen	Chk.	C. Hoplin	App.	
	Date	07/06/2022	Date	07/06/2022	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90					

Wallap Surcharge Summary for Section 1

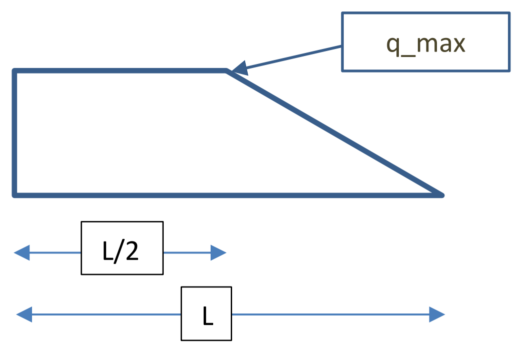
The surcharge from the Cooper E-80 loading is 80 kip per axle at 5-ft O.C. = 16 kip/ft

The surcharge is transferred to the approach slab that is connected to the back of the abutment.

The approach slab dimensions are 15 feet long by 12 feet wide.

The approach slab is essentially pinned to the back of the abutment and supported on the soil beyond. Since the reaction from the soil is softer than the reaction from the abutment, the abutment will take a portion of the total load. The total load applies to the approach slab is 16 kip/ft * 15 ft = 240 kip.

We conservatively assume the abutment takes 20 percent of the total load and the soil supports the remainder. 0.8 * 240kip = 192 kip. The weight of the soil and the approach slab is assumed to be 1.25 ft * 120 pcf + 1 ft * 150 pcf * 12 ft * 15 ft = 54 kip. We assume that the distribution of the soil pressure is trapezoidal as shown in the sketch below:



q_{max} = (192 kip+ 54 kip) * (2/3) / (12ft * 7.5 ft)

q_{max} = 1.82 ksf

The surcharge is applied to the soil below the approach slab at about El. 952.25. The bottom of the pile cap is at about El. 948 so there are 4.25 additional feet to spread the load into the embankment fill transverse to the railroad. We assume that this distributes the load on a 1.5 V to 1 H. Therefore, the effective width of the surcharge when it reaches El. 948 is equal to

4.25 ft / 1.5 * 2 + 12 ft = 17.67 ft. This will reduce the q_{max} by 12 ft / 17.67 ft = 0.68

q_{max_1} = 1.82 ksf * 0.68 = 1.24 ksf

The model assumes that the ground surface is at the top of the sheet pile (El. 949.65). Therefore, we add the weight of the embankment fill from El. 952.25 to El. 949.65. 2.6 ft * 120 pcf = 312 psf. This can be added to the q_{max_1} which will now be 1.24 ksf + 0.31 ksf = 1.55 ksf.

Beyond the end of the approach slab, the Cooper E-80 surcharge is applied to the 8.5-ft-wide tie at about El. 953. Using the same load spreading analogy, the railroad surcharge load at El. 948 is

16 kip/ft / [(953 ft – 948 ft) / 1.5 * 2 + 8.5ft] = 1.05 ksf.

The weight of the embankment adds another 4.35 ft * 120 pcf = 522 psf. So the surcharge beyond the end of the approach slab is 1.05 ksf + 0.52 ksf = 1.57 ksf starting 15 feet from the back of the abutment.

GEI Consultants	Client	HDR Engineering, Inc.			Page	
	Project	MassDOT Berkshire Line Bridges			Pg. Rev.	
	By	J. Christensen	Chk.	C. Hoplin	App.	
	Date	07/06/2022	Date	07/06/2022	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90					

Wallap Surcharge Summary for Section 2

The top of sheet pile for Section 2 is at El. 953. The top of the embankment is at about El. 954.

We assume the weight of the embankment in this area is 125 pcf. Therefore, we apply a surcharge of 125 psf starting at a distance of 1 foot from the wall to account for the weight of the embankment above the top of the sheet piles.

The using a similar distribution as Section 1, the maximum surcharge pressure under the approach slab is

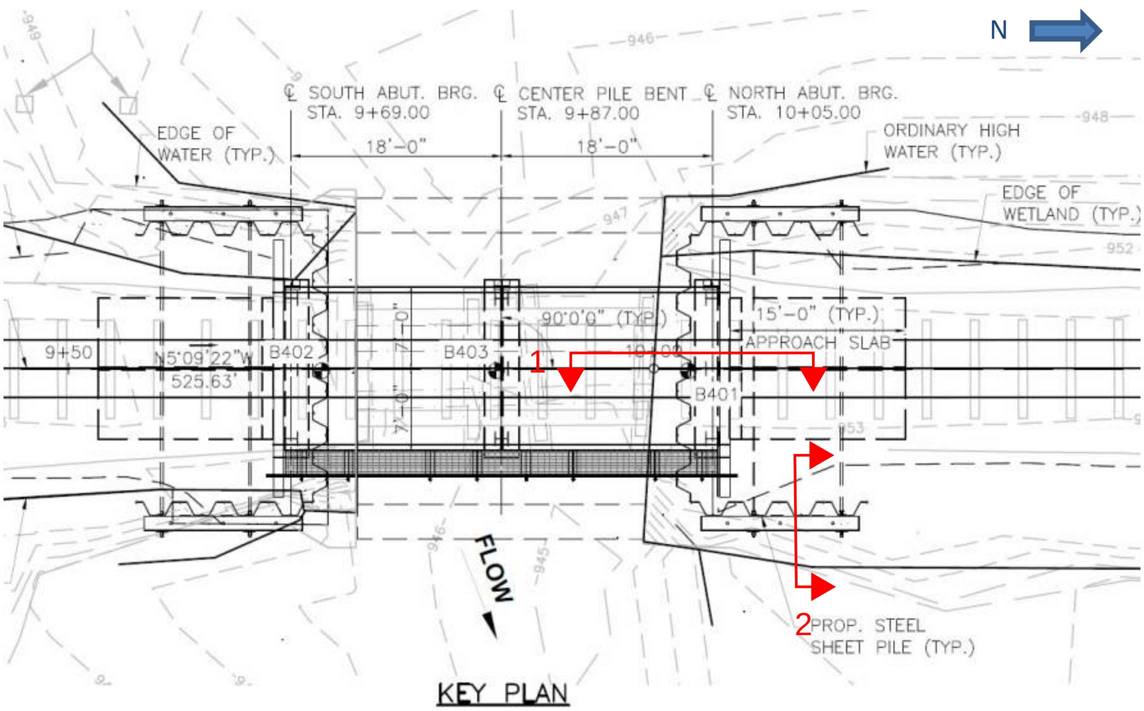
We conservatively assume the abutment takes 20 percent of the total load and the soil supports the remainder. 0.8 * 240kip = 192 kip. The maximum pressure under the approach slab is:

q_{max} = (192 kip) * (2/3) / (12ft * 7.5 ft) = 1.42 ksf. We will increase this by 30 pcf to account for the extra weight of the approach slab versus embankment soil. 1.42 ksf + 0.03 ksf = 1.45 ksf.

This surcharge is assumed to be 5 feet from the sheet pile wall.

The wale and tierod are assumed to be at El. 949.5 which is 2.75 feet below the bottom of the approach slab.

	Client	HDR Engineering, Inc.			Page	
GEI Consultants	Project	MassDOT Berkshire Line Bridges			Pg. Rev.	
	By	J. Christensen	Chk.	C. Hoplin	App.	
	Date	07/06/2022	Date	07/06/2022	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90					



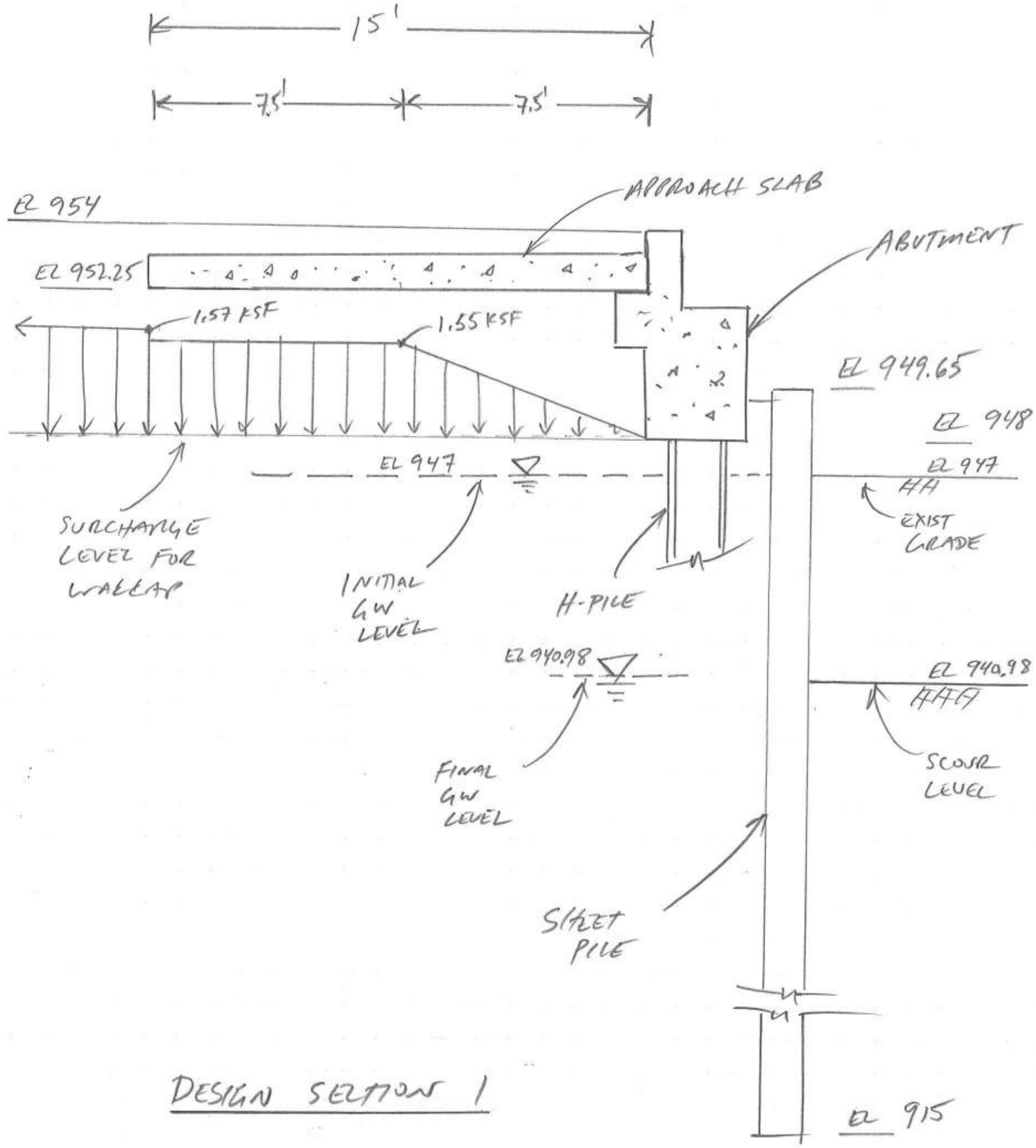
Summary of WALLAP Results

Design Section 1 is cantilevered. Design Section 2 has a support consisting of a wale and tierods at El. 949.5. The WALLAP results for a stream scour level was El. 940.98 are presented below.

Design Section	Max Moment in Sheet Pile (kip-ft/ft)	Max Shear in Sheet Pile (kip/ft)	Estimated Deflection (in)	Line Load at Wale (kip/ft)	Sheet Pile Toe Elevation (Elev., ft)
Design Section 1	22.7	2.6	~ 1.0	N/A	915
Design Section 2	17.1	3.9	< 1.0	4.4	925.5

GEI Consultants	Client				Page	
	Project				Pg. Rev.	
	By		Chk.		App.	
	Date		Date		Date	

Project No.		Document No.	
Subject			



DESIGN SECTION 1

Units: lb,ft

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Left side	Soil types Right side
1	949.65	1 FILL/SILT/SAND	1 FILL/SILT/SAND

SOIL PROPERTIES

-- Soil type -- No. Description (Datum elev.)	Bulk density lb/ft3	Young's Modulus Eh,lb/ft2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion lb/ft2 (dc/dy)
1 FILL/SILT/-SAND	125.0	0 (40000)	0.500	NC (0.330)	0.292 (0.000)	4.000 (0.000)	

GROUND WATER CONDITIONS

Density of water = 62.50 lb/ft3

	Left side	Right side
Initial water table elevation	947.00	947.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side Point no.	Elev. ft	Piezo elev. ft	Water press. lb/ft2	Right side Point no.	Elev. ft	Piezo elev. ft	Water press. lb/ft2
1	1	940.98	940.98	0.0	1	940.98	940.98	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 914.00
Maximum finite element length = 2.00 ft
Youngs modulus of wall E = 4.1760E+09 lb/ft2
Moment of inertia of wall I = 0.017400 ft4/ft run
E.I = 7.2662E+07 lb.ft2/ft run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge lb/ft2 Near edge	Surcharge lb/ft2 Far edge	Equiv. soil type	Partial factor/ Category
1	948.00	3.00(L)	100.00	7.50	312.00	1550.00	0	N/A
2	948.00	10.50(L)	100.00	7.50	1550.00	=	0	N/A
3	948.00	18.00(L)	100.00	100.00	1570.00	=	0	N/A

Note: L = Left side, R = Right side
A trapezoidal surcharge is defined by two values:
N = at edge near to wall, F = at edge far from wall

CONSTRUCTION STAGES

```
Construction   Stage description
  stage no.    -------------------------------------------------------
      1        Excavate to elevation 947.00 on RIGHT side
      2        Apply surcharge no.1 at elevation 948.00
               No analysis at this stage
      3        Apply surcharge no.2 at elevation 948.00
               No analysis at this stage
      4        Apply surcharge no.3 at elevation 948.00
      5        Excavate to elevation 940.98 on RIGHT side
      6        Apply water pressure profile no.1
```

FACTORS OF SAFETY and ANALYSIS OPTIONS

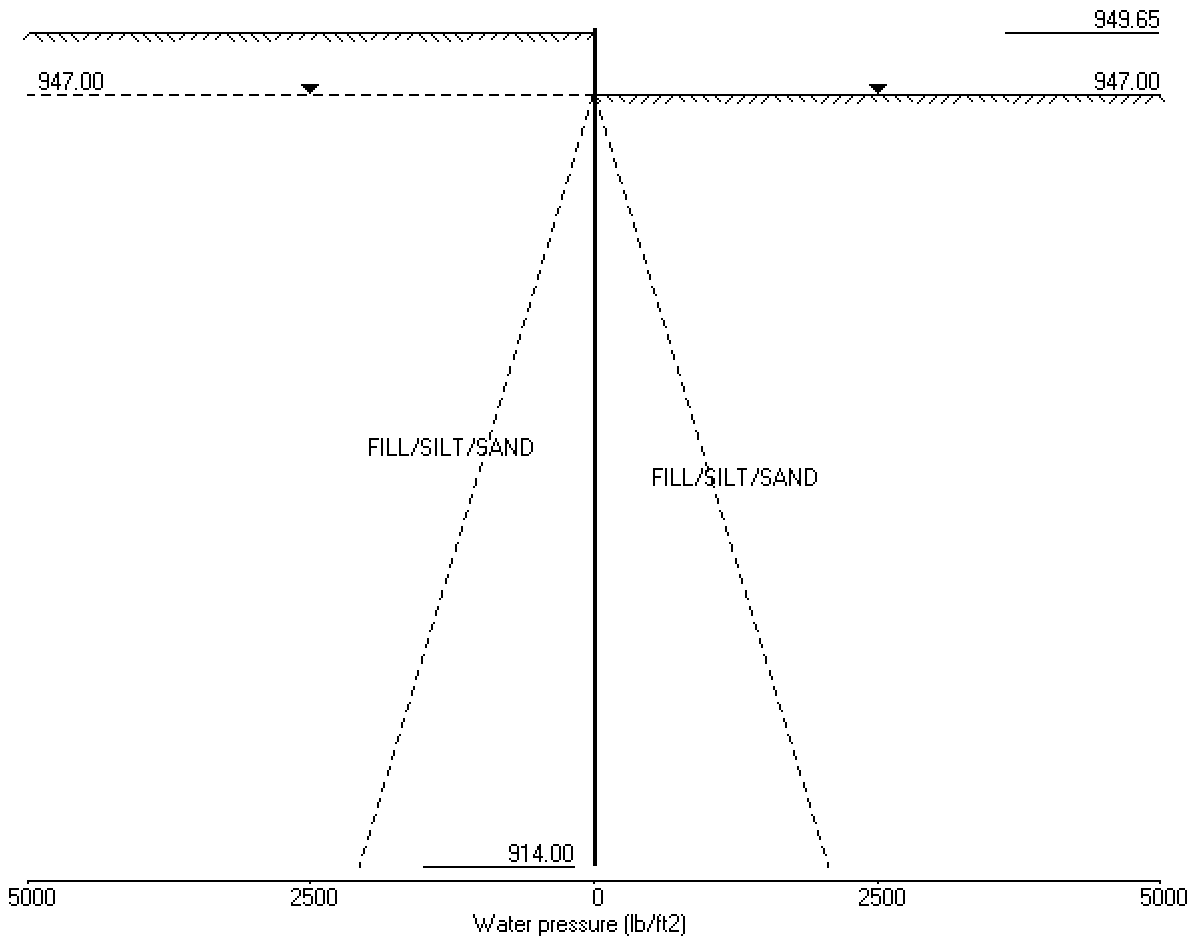
```
 Stability analysis:
  Method of analysis  -  CP2
  Factor on passive for calculating wall depth = 2.00
  Active limit pressures calculated by Wedge Stability

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   0.00 lb/ft3
  Maximum depth of water filled tension crack  =   0.00 ft

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 35.00 ft

 Boundary conditions:
  Length of wall (normal to plane of analysis) = 1000.00 ft

  Width of excavation on Left  side of wall  = 100.00 ft
  Width of excavation on Right side of wall  = 100.00 ft

  Distance to rigid boundary on Left side  = 100.00 ft
  Distance to rigid boundary on Right side = 100.00 ft
```

OUTPUT OPTIONS

```
 Stage ------ Stage description ----------- ------- Output options -------
  no.                                       Displacement   Active,  Graph.
                                            Bending mom.   Passive  output
                                            Shear force   pressures
   1 Excav. to elev. 947.00 on RIGHT side       Yes          Yes     Yes
   2 Apply surcharge no.1 at elev. 948.00        No           No      No
   3 Apply surcharge no.2 at elev. 948.00        No           No      No
   4 Apply surcharge no.3 at elev. 948.00       Yes          Yes     Yes
   5 Excav. to elev. 940.98 on RIGHT side       Yes          Yes     Yes
   6 Apply water pressure profile no.1          Yes          Yes     Yes
   * Summary output                             Yes           -      Yes
```

Units: lb,ft

Stage No.1 Excav. to elev. 947.00 on RIGHT side



Units: lb,ft

Stage No. 1 Excavate to elevation 947.00 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = 914.00 Factor of Safety	FoS for toe elev. = 914.00 Moment equilib. at elev.	Toe elev. for FoS = 2.000 Toe elev.	Toe elev. for FoS = 2.000 Wall Penetr -ation	Direction of failure
1	949.65	947.00	Cant.	8.661	917.47	942.00	5.00	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	949.65	0.00	0.007	4.39E-04	0.0	0.0	
2	948.00	61.74	0.006	4.39E-04	50.9	46.8	
3	947.00	103.64	0.006	4.38E-04	133.6	139.0	
4	945.50	42.94	0.005	4.31E-04	243.6	455.1	
5	944.00	-0.10	0.005	4.18E-04	275.7	868.8	
6	942.49	-29.22	0.004	3.95E-04	253.6	1285.0	
7	940.98	-45.79	0.004	3.65E-04	196.9	1634.5	
8	939.49	-52.00	0.003	3.29E-04	124.1	1877.1	
9	938.00	-50.53	0.003	2.89E-04	47.7	2004.3	
10	936.00	-40.63	0.002	2.34E-04	-43.5	1998.6	
11	934.00	-26.36	0.002	1.81E-04	-110.5	1830.3	
12	932.00	-11.81	0.001	1.35E-04	-148.6	1556.7	
13	930.00	0.37	0.001	9.68E-05	-160.1	1235.7	
14	928.00	8.86	0.001	6.72E-05	-150.8	916.3	
15	926.00	13.48	0.001	4.59E-05	-128.5	632.2	
16	924.00	14.80	0.001	3.17E-05	-100.2	402.1	
17	922.00	13.77	0.001	2.29E-05	-71.6	231.1	
18	920.00	11.44	0.001	1.82E-05	-46.4	115.2	
19	918.00	8.74	0.001	1.60E-05	-26.3	45.0	
20	916.00	6.38	0.001	1.52E-05	-11.1	9.7	
21	914.00	4.76	0.001	1.51E-05	-0.0	-0.0	

		LEFT side						
				Effective stresses			Total	Coeff. of
Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	earth pressure lb/ft2	subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	1061
2	948.00	0.00	206.25	59.67	825.00	61.74	61.74	6368
3	947.00	0.00	331.25	95.93	1325.00	103.64	103.64	10227
4	945.50	93.75	425.00	122.93	1700.00	125.90	219.65	16016

(continued)

Stage No.1 Excavate to elevation 947.00 on RIGHT side

LEFT side

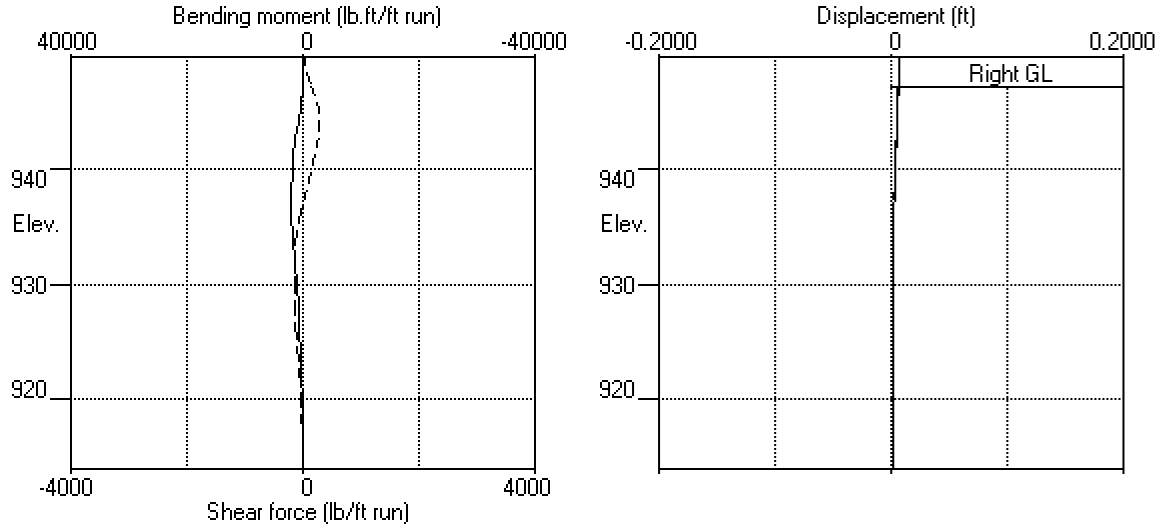
Node no.	Y coord	Water press. lb/ft2	Vertic-al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	944.00	187.50	518.75	150.33	2075.00	155.39	342.89	21805
6	942.49	281.87	613.13	177.92	2452.50	191.80	473.68	27632
7	940.98	376.25	707.50	205.50	2830.00	234.05	610.30	33459
8	939.49	469.37	800.63	232.72	3202.50	280.37	749.74	39210
9	938.00	562.50	893.75	259.96	3575.00	330.10	892.60	44960
10	936.00	687.50	1018.75	296.47	4075.00	400.17	1087.67	52678
11	934.00	812.50	1143.75	333.01	4575.00	471.78	1284.28	60397
12	932.00	937.50	1268.75	369.54	5075.00	543.01	1480.51	68115
13	930.00	1062.50	1393.75	406.07	5575.00	612.65	1675.15	75833
14	928.00	1187.50	1518.75	442.61	6075.00	680.16	1867.66	83552
15	926.00	1312.50	1643.75	479.14	6575.00	745.56	2058.06	91270
16	924.00	1437.50	1768.75	515.67	7075.00	809.19	2246.69	98989
17	922.00	1562.50	1893.75	552.21	7575.00	871.58	2434.08	106707
18	920.00	1687.50	2018.75	588.74	8075.00	933.29	2620.79	114425
19	918.00	1812.50	2143.75	625.27	8575.00	994.81	2807.31	122144
20	916.00	1937.50	2268.75	665.01	9075.00	1056.48	2993.98	129862
21	914.00	2062.50	2393.75	705.06	9575.00	1118.53	3181.03	137581

RIGHT side

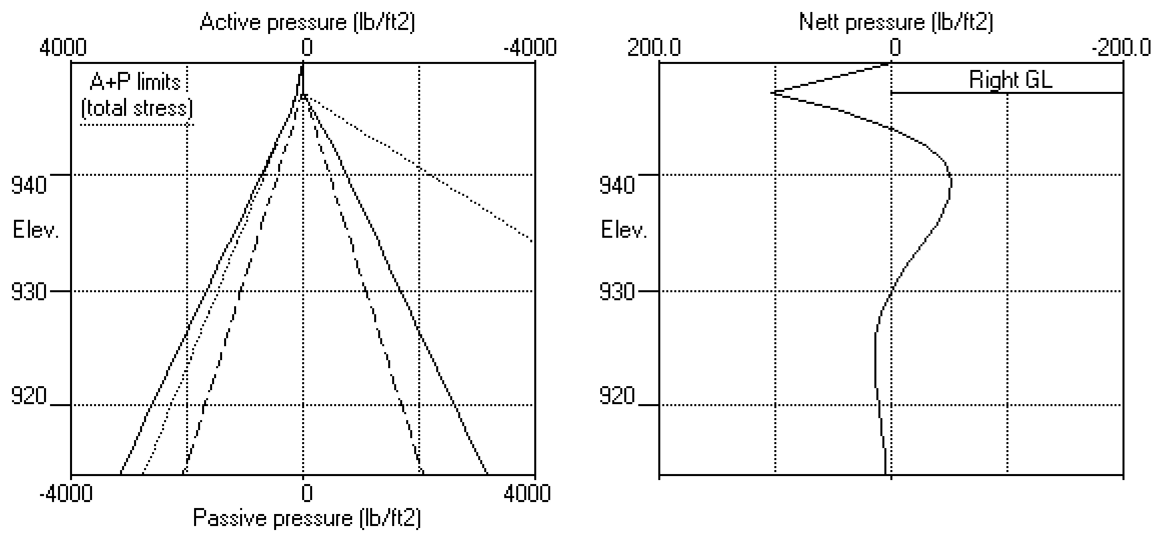
Node no.	Y coord	Water press. lb/ft2	Vertic-al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	948.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	1036
4	945.50	93.75	93.75	25.88	375.00	82.95	176.70	6215
5	944.00	187.50	187.50	53.58	750.02	155.50	343.00	12429
6	942.49	281.87	281.89	81.21	1127.55	221.02	502.89	18685
7	940.98	376.25	376.28	108.81	1505.12	279.84	656.09	24941
8	939.49	469.37	469.43	136.03	1877.74	332.37	801.74	31115
9	938.00	562.50	562.60	163.26	2250.41	380.62	943.12	37288
10	936.00	687.50	687.68	199.76	2750.74	440.79	1128.29	45574
11	934.00	812.50	812.80	236.31	3251.21	498.14	1310.64	53860
12	932.00	937.50	937.96	272.85	3751.85	554.81	1492.31	62146
13	930.00	1062.50	1063.17	309.38	4252.67	612.28	1674.78	70433
14	928.00	1187.50	1188.42	345.91	4753.70	671.31	1858.81	78719
15	926.00	1312.50	1313.74	382.45	5254.94	732.08	2044.58	87005
16	924.00	1437.50	1439.11	418.98	5756.43	794.39	2231.89	95291
17	922.00	1562.50	1564.54	455.52	6258.17	857.81	2420.31	103577
18	920.00	1687.50	1690.04	492.05	6760.17	921.85	2609.35	111864
19	918.00	1812.50	1815.61	528.58	7262.45	986.06	2798.56	120150
20	916.00	1937.50	1941.25	568.39	7765.00	1050.11	2987.61	128436
21	914.00	2062.50	2066.96	608.66	8267.84	1113.77	3176.27	136722

Units: lb,ft

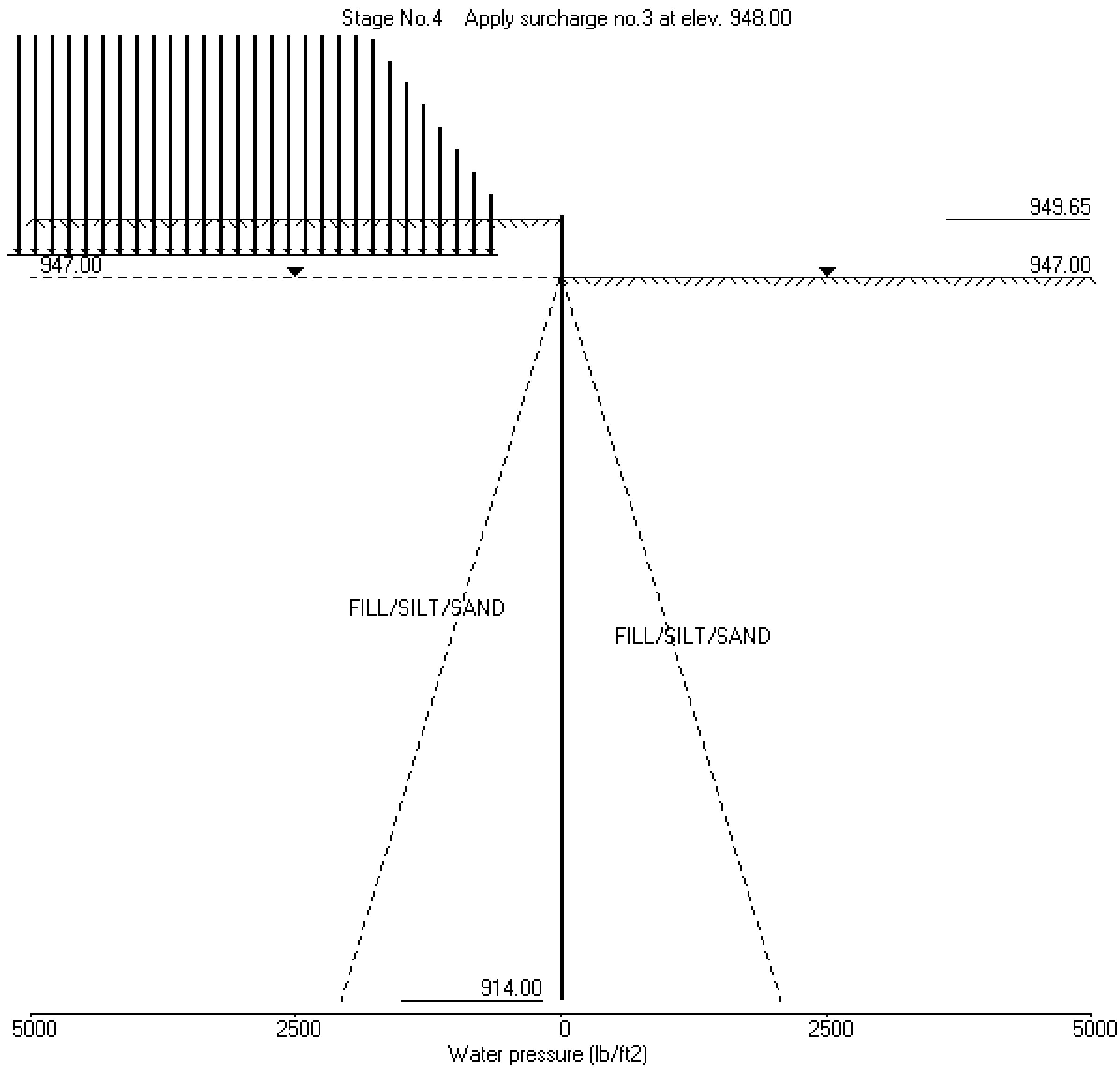
Stage No.1 Excav. to elev. 947.00 on RIGHT side



Stage No.1 Excav. to elev. 947.00 on RIGHT side



Units: lb,ft


Stage No.4 Apply surcharge no.3 at elev. 948.00
949.65
947.00
947.00
FILL/SILT/SAND
FILL/SILT/SAND
914.00
5000
2500
0
2500
5000
Water pressure (lb/ft2)

Units: lb,ft

Stage No. 4 Apply surcharge no.3 at elevation 948.00

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 914.00		Toe elev. for FoS = 2.000		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
4	949.65	947.00	Cant.	4.583	915.74	940.97	6.03	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	949.65	0.00	0.021	8.48E-04	0.0	0.0	
2	948.00	62.44	0.020	8.48E-04	51.5	47.1	
3	947.00	101.40	0.019	8.47E-04	133.4	139.8	
4	945.50	0.62	0.018	8.40E-04	209.9	456.9	
5	944.00	-2.35	0.016	8.27E-04	208.6	804.6	
6	942.49	24.19	0.015	8.07E-04	225.1	1153.5	
7	940.98	-17.74	0.014	7.79E-04	230.0	1524.7	
8	939.49	-30.22	0.013	7.45E-04	194.3	1856.3	
9	938.00	-1.48	0.012	7.04E-04	170.7	2131.4	
10	936.00	-3.33	0.010	6.40E-04	165.8	2478.5	
11	934.00	-53.74	0.009	5.68E-04	108.8	2771.6	
12	932.00	-73.86	0.008	4.88E-04	-18.8	3075.9	
13	930.00	-48.77	0.007	4.05E-04	-141.5	2903.4	
14	928.00	-25.97	0.006	3.30E-04	-216.2	2533.8	
15	926.00	-7.43	0.006	2.67E-04	-249.6	2058.8	
16	924.00	6.22	0.005	2.18E-04	-250.8	1552.8	
17	922.00	15.54	0.005	1.81E-04	-229.1	1070.5	
18	920.00	22.00	0.005	1.58E-04	-191.5	649.0	
19	918.00	27.64	0.004	1.45E-04	-141.9	314.1	
20	916.00	34.66	0.004	1.39E-04	-79.6	88.4	
21	914.00	44.92	0.004	1.38E-04	-0.0	0.0	

		LEFT side						
			Effective stresses				Total	Coeff. of
Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	earth pressure lb/ft2	subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	739
2	948.00	0.00	206.25	62.44	825.00	62.44	62.44a	4433
3	947.00	0.00	338.90	101.40	1355.61	101.40	101.40a	7119
4	945.50	93.75	504.15	133.98	2016.59	133.98	227.73a	11149

(continued)

Stage No.4 Apply surcharge no.3 at elevation 948.00

LEFT side

Node no.	Y coord	Water press. lb/ft2	Effective stresses: Vertic -al lb/ft2	Effective stresses: Active limit lb/ft2	Effective stresses: Passive limit lb/ft2	Effective stresses: Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	944.00	187.50	716.65	248.86	2866.58	248.86	436.36a	15179
6	942.49	281.87	937.27	381.34	3749.10	381.34	663.22a	19236
7	940.98	376.25	1148.59	433.40	4594.37	433.40	809.65a	23292
8	939.49	469.37	1343.87	502.95	5375.46	502.95	972.33a	27295
9	938.00	562.50	1525.77	604.34	6103.06	604.34	1166.84a	31298
10	936.00	687.50	1750.82	687.62	7003.30	687.62	1375.12a	36671
11	934.00	812.50	1957.15	711.37	7828.59	711.37	1523.87a	42044
12	932.00	937.50	2148.03	748.66	8592.10	758.13	1695.63	47417
13	930.00	1062.50	2326.23	751.26	9304.94	846.40	1908.90	52791
14	928.00	1187.50	2494.01	805.09	9976.06	931.35	2118.85	58164
15	926.00	1312.50	2653.14	909.97	10612.58	1012.54	2325.04	63537
16	924.00	1437.50	2805.03	970.14	11220.14	1089.97	2527.47	68910
17	922.00	1562.50	2950.82	1047.00	11803.26	1164.03	2726.53	74283
18	920.00	1687.50	3091.40	1077.68	12365.61	1235.50	2923.00	79656
19	918.00	1812.50	3227.54	991.65	12910.18	1305.42	3117.92	85029
20	916.00	1937.50	3359.87	1006.78	13439.47	1374.90	3312.40	90402
21	914.00	2062.50	3488.90	1093.56	13955.59	1444.94	3507.44	95775

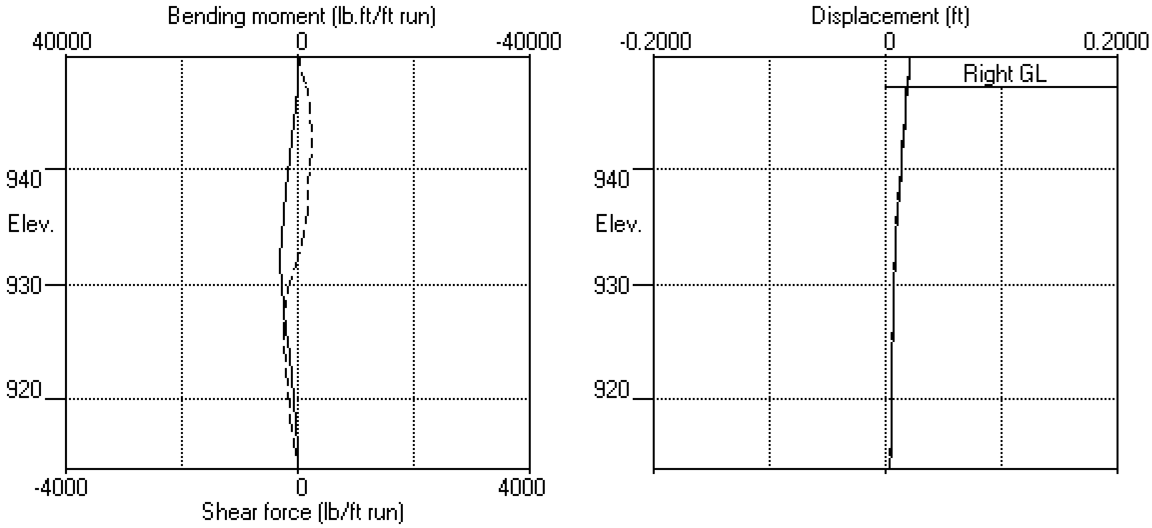
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Effective stresses: Vertic -al lb/ft2	Effective stresses: Active limit lb/ft2	Effective stresses: Passive limit lb/ft2	Effective stresses: Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	948.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	693
4	945.50	93.75	93.75	25.88	375.00	133.36	227.11	4161
5	944.00	187.50	187.50	53.58	750.02	251.21	438.71	8321
6	942.49	281.87	281.89	81.21	1127.55	357.15	639.03	12510
7	940.98	376.25	376.28	108.81	1505.12	451.13	827.38	16698
8	939.49	469.37	469.43	136.03	1877.74	533.18	1002.55	20831
9	938.00	562.50	562.60	163.26	2250.41	605.82	1168.32	24964
10	936.00	687.50	687.68	199.76	2750.74	690.95	1378.45	30512
11	934.00	812.50	812.80	236.31	3251.21	765.11	1577.61	36059
12	932.00	937.50	937.96	272.85	3751.85	831.99	1769.49	41607
13	930.00	1062.50	1063.17	309.38	4252.67	895.18	1957.68	47154
14	928.00	1187.50	1188.42	345.91	4753.70	957.32	2144.82	52702
15	926.00	1312.50	1313.74	382.45	5254.94	1019.98	2332.48	58249
16	924.00	1437.50	1439.11	418.98	5756.43	1083.75	2521.25	63797
17	922.00	1562.50	1564.54	455.52	6258.17	1148.49	2710.99	69345
18	920.00	1687.50	1690.04	492.05	6760.17	1213.50	2901.00	74892
19	918.00	1812.50	1815.61	528.58	7262.45	1277.77	3090.27	80440
20	916.00	1937.50	1941.25	568.39	7765.00	1340.24	3277.74	85987
21	914.00	2062.50	2066.96	608.66	8267.84	1400.02	3462.52	91535

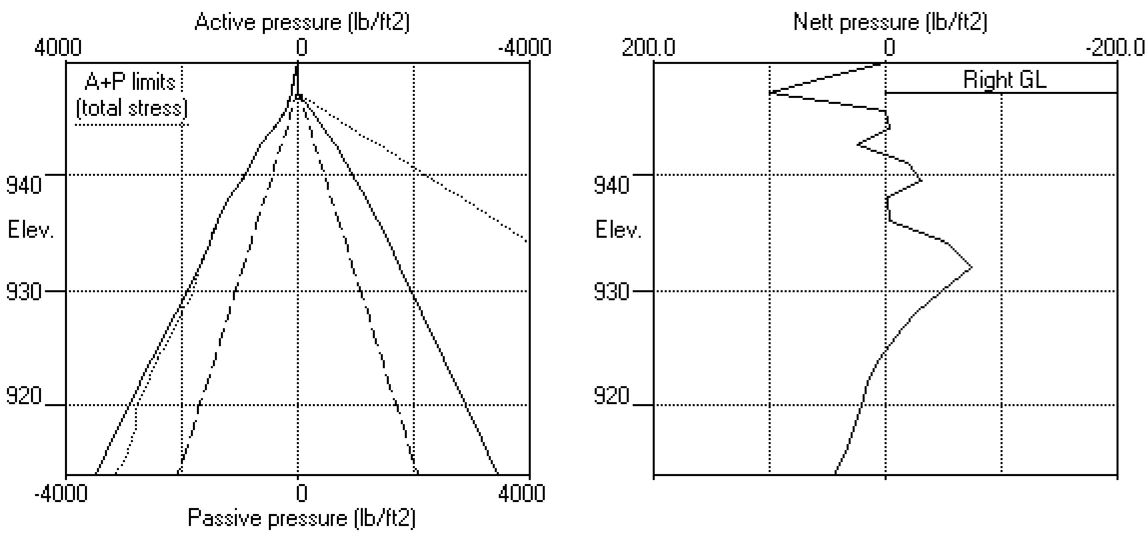
Note: 1523.87a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: lb,ft

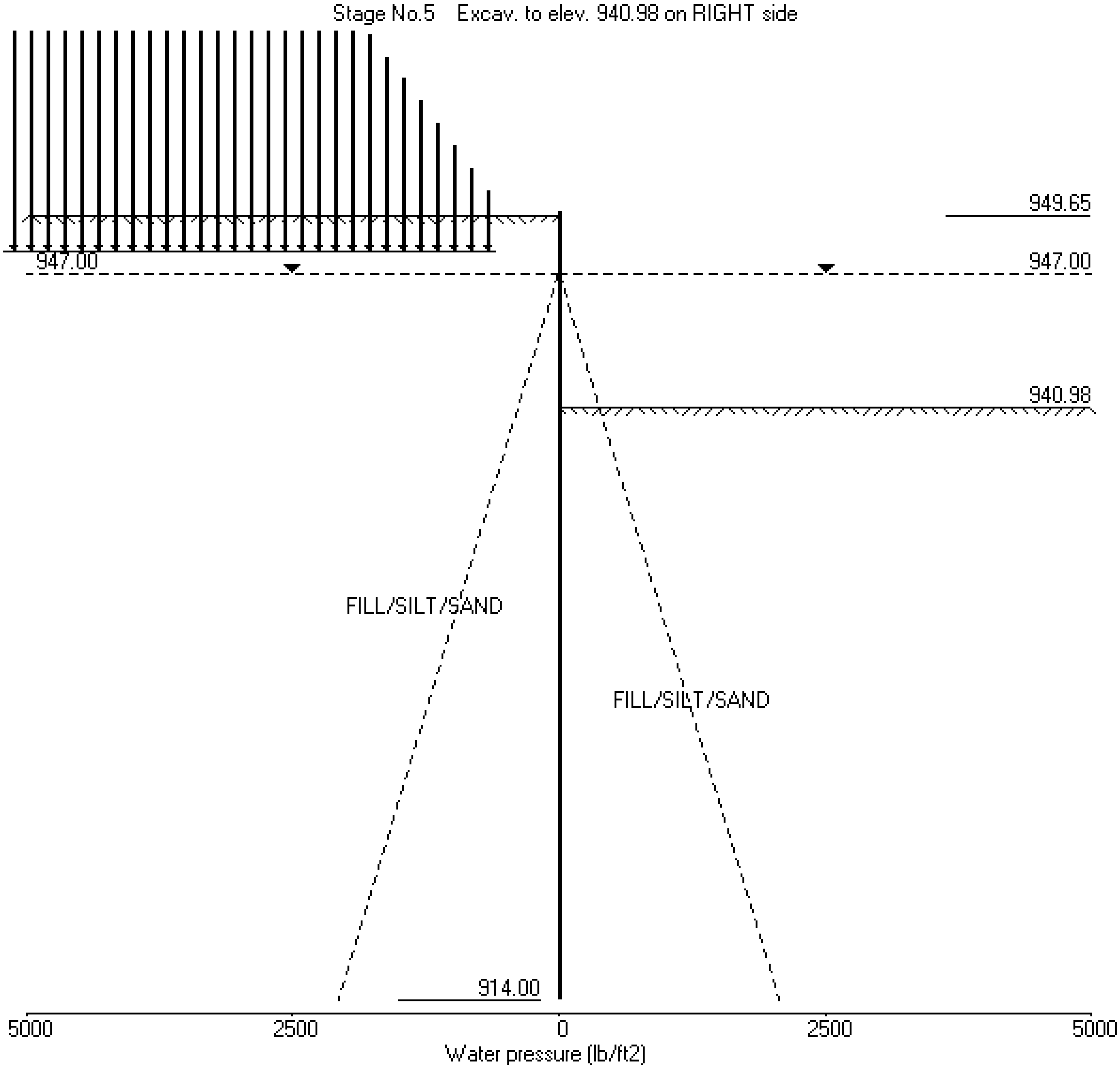
Stage No.4 Apply surcharge no.3 at elev. 948.00



Stage No.4 Apply surcharge no.3 at elev. 948.00



Units: lb,ft


Stage No.5 Excav. to elev. 940.98 on RIGHT side
949.65
947.00
947.00
940.98
FILL/SILT/SAND
FILL/SILT/SAND
914.00
5000
2500
0
2500
5000
Water pressure (lb/ft2)

Units: lb,ft

Stage No. 5 Excavate to elevation 940.98 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 914.00		Toe elev. for FoS = 2.000		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
5	949.65	940.98	Cant.	2.389	916.00	918.58	22.40	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	949.65	0.00	0.086	4.21E-03	0.0	0.0	
2	948.00	62.44	0.079	4.21E-03	51.5	47.1	
3	947.00	101.40	0.075	4.21E-03	133.4	139.8	
4	945.50	133.98	0.069	4.20E-03	310.0	507.0	
5	944.00	248.86	0.062	4.19E-03	597.1	1198.8	
6	942.49	381.34	0.056	4.15E-03	1072.9	2460.9	
7	940.98	433.40	0.050	4.08E-03	1688.0	4555.2	
8	939.49	130.45	0.044	3.95E-03	2108.1	7452.6	
9	938.00	-140.69	0.038	3.77E-03	2100.5	10646.6	
10	936.00	-308.68	0.031	3.42E-03	1651.1	14791.3	
11	934.00	-381.53	0.024	2.97E-03	960.9	17444.2	
12	932.00	-367.84	0.019	2.48E-03	211.5	18790.9	
13	930.00	-345.47	0.014	1.96E-03	-501.8	18434.0	
14	928.00	-255.18	0.011	1.48E-03	-1102.4	16729.6	
15	926.00	-117.96	0.008	1.06E-03	-1475.6	14039.5	
16	924.00	-42.86	0.007	7.18E-04	-1636.4	10849.0	
17	922.00	79.92	0.006	4.64E-04	-1599.3	7577.2	
18	920.00	160.72	0.005	2.97E-04	-1358.7	4543.9	
19	918.00	205.24	0.004	2.05E-04	-992.7	2152.1	
20	916.00	248.47	0.004	1.67E-04	-539.0	579.8	
21	914.00	290.55	0.004	1.60E-04	0.0	0.0	

		LEFT side						
			Effective stresses					
Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	989
2	948.00	0.00	206.25	62.44	825.00	62.44	62.44a	5932
3	947.00	0.00	338.90	101.40	1355.61	101.40	101.40a	9527
4	945.50	93.75	504.15	133.98	2016.59	133.98	227.73a	14919

(continued)

Stage No.5 Excavate to elevation 940.98 on RIGHT side

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	944.00	187.50	716.65	248.86	2866.58	248.86	436.36a	20312
6	942.49	281.87	937.27	381.34	3749.10	381.34	663.22a	25740
7	940.98	376.25	1148.59	433.40	4594.37	433.40	809.65a	31168
8	939.49	469.37	1343.87	502.95	5375.46	502.95	972.33a	36525
9	938.00	562.50	1525.77	604.34	6103.06	604.34	1166.84a	41881
10	936.00	687.50	1750.82	687.62	7003.30	687.62	1375.12a	49071
11	934.00	812.50	1957.15	711.37	7828.59	711.37	1523.87a	56261
12	932.00	937.50	2148.03	748.66	8592.10	748.66	1686.16a	63451
13	930.00	1062.50	2326.23	751.26	9304.94	751.26	1813.76a	70641
14	928.00	1187.50	2494.01	805.09	9976.06	805.09	1992.59a	77831
15	926.00	1312.50	2653.14	909.97	10612.58	909.97	2222.47a	85021
16	924.00	1437.50	2805.03	970.14	11220.14	970.14	2407.64a	92211
17	922.00	1562.50	2950.82	1047.00	11803.26	1100.96	2663.46	99401
18	920.00	1687.50	3091.40	1077.68	12365.61	1211.59	2899.09	106591
19	918.00	1812.50	3227.54	991.65	12910.18	1301.58	3114.08	113781
20	916.00	1937.50	3359.87	1006.78	13439.47	1391.43	3328.93	336037
21	914.00	2062.50	3488.90	1093.56	13955.59	1479.54	3542.04	356009

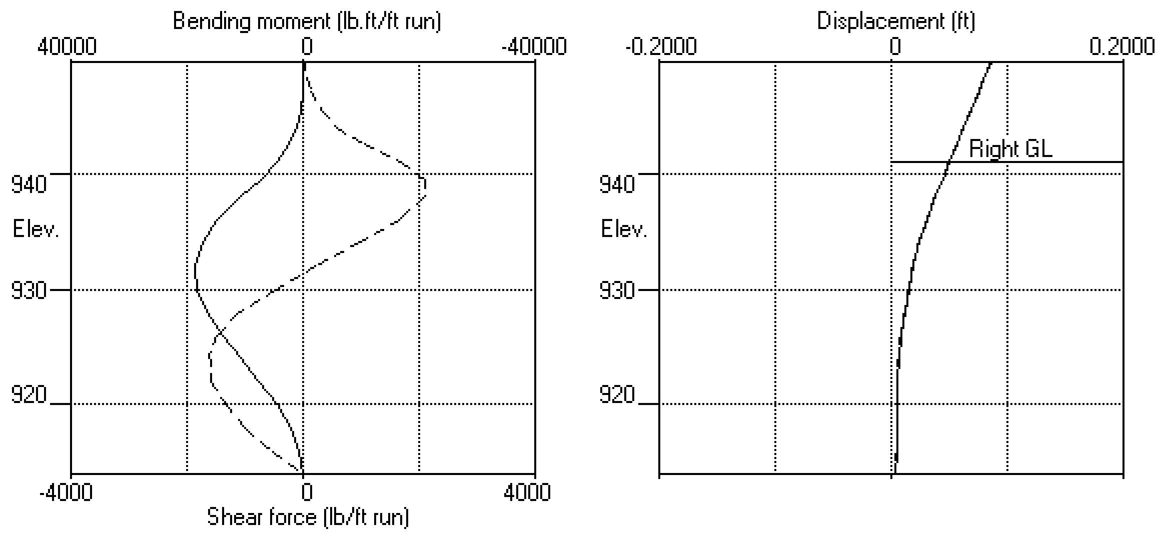
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	948.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	945.50	93.75	0.00	0.00	0.00	0.00	93.75	0.0
5	944.00	187.50	0.00	0.00	0.00	0.00	187.50	0.0
6	942.49	281.87	0.00	0.00	0.00	0.00	281.87	0.0
7	940.98	376.25	0.00	0.00	0.00	0.00	376.25	0.0
		376.25	0.00	0.00	0.00	0.00	376.25	1194
8	939.49	469.37	93.13	31.89	372.50	372.50	841.88p	7164
9	938.00	562.50	186.26	56.86	745.03	745.03	1307.53p	14328
10	936.00	687.50	311.29	93.09	1245.15	996.30	1683.80	23945
11	934.00	812.50	436.35	130.79	1745.41	1092.90	1905.40	33561
12	932.00	937.50	561.47	169.22	2245.86	1116.49	2053.99	43177
13	930.00	1062.50	686.64	206.85	2746.57	1096.72	2159.22	52793
14	928.00	1187.50	811.89	243.06	3247.57	1060.27	2247.77	62410
15	926.00	1312.50	937.23	278.16	3748.93	1027.93	2340.43	72026
16	924.00	1437.50	1062.67	313.50	4250.68	1013.00	2450.50	81642
17	922.00	1562.50	1188.22	356.05	4752.87	1021.04	2583.54	91259
18	920.00	1687.50	1313.88	394.90	5255.53	1050.86	2738.36	100875
19	918.00	1812.50	1439.68	431.90	5758.70	1096.34	2908.84	110491
20	916.00	1937.50	1565.60	471.31	6262.41	1142.95	3080.45	249456
21	914.00	2062.50	1691.67	509.32	6766.68	1188.99	3251.49	269428

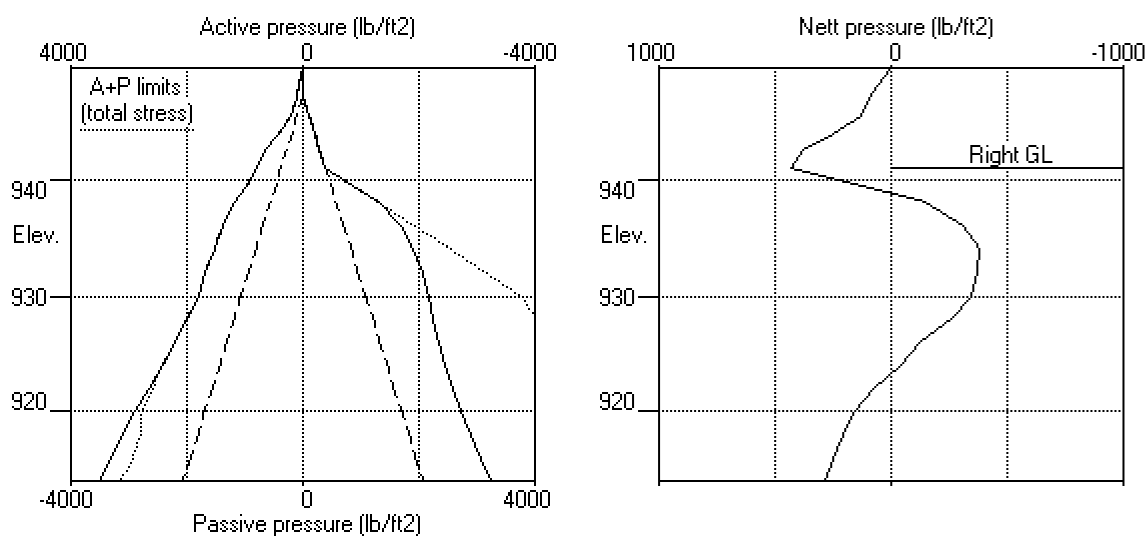
Note: 2407.64a Soil pressure at active limit
1307.53p Soil pressure at passive limit

Units: lb,ft

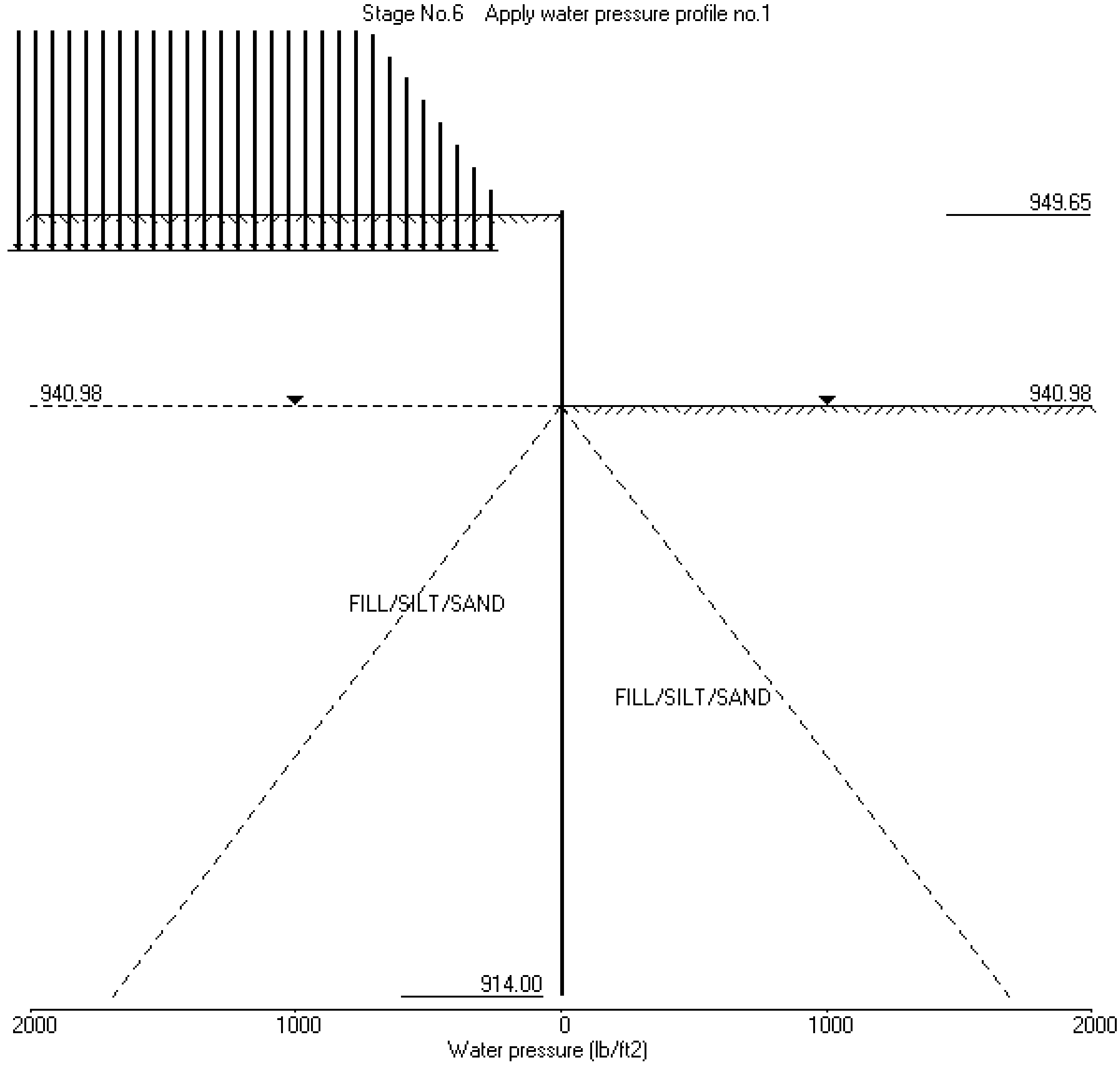
Stage No.5 Excav. to elev. 940.98 on RIGHT side



Stage No.5 Excav. to elev. 940.98 on RIGHT side



Units: lb,ft


Stage No.6 Apply water pressure profile no.1
949.65
940.98
940.98
FILL/SILT/SAND
FILL/SILT/SAND
914.00
2000
1000
0
1000
2000
Water pressure (lb/ft2)

Units: lb,ft

Stage No. 6 Apply water pressure profile no.1

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = 914.00: Factor of Safety	FoS for toe elev. = 914.00: Moment equilib. at elev.	Toe elev. for FoS = 2.000: Toe elev.	Toe elev. for FoS = 2.000: Wall Penetr -ation	Direction of failure
6	949.65	940.98	Cant.	2.106	915.80	915.42	25.56	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	949.65	0.00	0.108	5.15E-03	0.0	0.0	
2	948.00	62.44	0.099	5.15E-03	51.5	47.1	
3	947.00	101.93	0.094	5.15E-03	133.7	139.9	
4	945.50	159.89	0.086	5.14E-03	330.1	517.6	
5	944.00	270.77	0.079	5.12E-03	653.1	1267.2	
6	942.49	431.33	0.071	5.08E-03	1183.1	2649.5	
7	940.98	539.33	0.063	5.00E-03	1916.0	4988.5	
8	939.49	214.61	0.056	4.87E-03	2477.7	8335.1	
9	938.00	-77.10	0.049	4.66E-03	2580.1	12165.6	
10	936.00	-383.05	0.040	4.25E-03	2120.0	17425.1	
11	934.00	-449.61	0.032	3.72E-03	1287.3	20889.7	
12	932.00	-459.96	0.025	3.12E-03	377.7	22743.0	
13	930.00	-424.80	0.019	2.50E-03	-507.0	22540.1	
14	928.00	-352.19	0.015	1.90E-03	-1284.0	20828.2	
15	926.00	-169.36	0.012	1.37E-03	-1805.6	17580.9	
16	924.00	-56.47	0.009	9.49E-04	-2031.4	13627.6	
17	922.00	94.60	0.008	6.30E-04	-1993.3	9538.5	
18	920.00	195.48	0.007	4.20E-04	-1703.2	5746.5	
19	918.00	255.15	0.006	3.03E-04	-1252.6	2735.1	
20	916.00	312.73	0.005	2.55E-04	-684.7	742.8	
21	914.00	371.95	0.005	2.45E-04	0.0	0.0	

LEFT side

Node no.	Y coord	Water press. lb/ft2	Effective stresses: Vertic -al lb/ft2	Effective stresses: Active limit lb/ft2	Effective stresses: Passive limit lb/ft2	Effective stresses: Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	898
2	948.00	0.00	206.25	62.44	825.00	62.44	62.44a	5386
3	947.00	0.00	338.90	101.93	1355.61	101.93	101.93a	8650
4	945.50	0.00	597.90	159.89	2391.59	159.89	159.89a	13546

(continued)

Stage No.6 Apply water pressure profile no.1

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	944.00	0.00	904.15	270.77	3616.58	270.77	270.77a	18442
6	942.49	0.00	1219.15	431.33	4876.60	431.33	431.33a	23371
7	940.98	0.00	1524.84	539.33	6099.37	539.33	539.33a	28300
8	939.49	93.13	1720.12	587.12	6880.46	587.12	680.24a	33164
9	938.00	186.25	1902.02	667.95	7608.06	667.95	854.20a	38027
10	936.00	311.25	2127.07	793.66	8508.30	793.66	1104.91a	44555
11	934.00	436.25	2333.40	851.47	9333.59	851.47	1287.72a	51084
12	932.00	561.25	2524.28	873.68	10097.10	873.68	1434.93a	57612
13	930.00	686.25	2702.48	884.95	10809.94	884.95	1571.20a	64140
14	928.00	811.25	2870.26	895.85	11481.06	909.65	1720.90	70669
15	926.00	936.25	3029.39	998.90	12117.58	1046.54	1982.79	77197
16	924.00	1061.25	3181.28	1062.72	12725.14	1132.22	2193.47	83725
17	922.00	1186.25	3327.07	1177.69	13308.26	1281.91	2468.16	90253
18	920.00	1311.25	3467.65	1197.72	13870.61	1406.06	2717.31	96782
19	918.00	1436.25	3603.79	1118.01	14415.18	1506.34	2942.59	103310
20	916.00	1561.25	3736.12	1141.58	14944.47	1605.60	3166.85	109838
21	914.00	1686.25	3865.15	1148.52	15460.59	1704.21	3390.46	116367

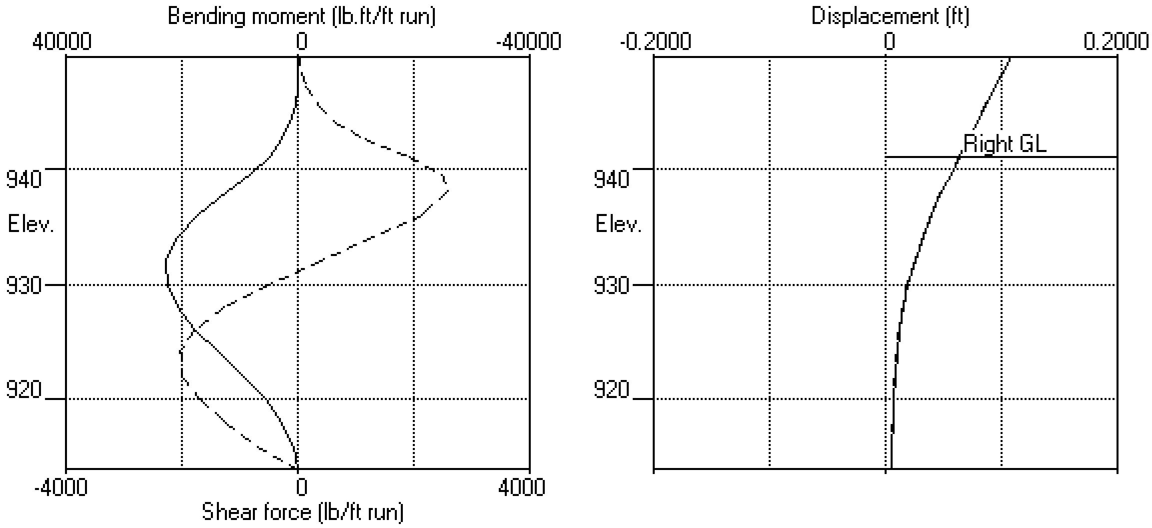
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	948.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	945.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	944.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	942.49	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	940.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	1002
8	939.49	93.13	93.13	25.68	372.51	372.51	465.63p	6014
9	938.00	186.25	186.26	53.23	745.05	745.05	931.30p	12027
10	936.00	311.25	311.31	89.79	1245.23	1176.70	1487.95	20100
11	934.00	436.25	436.41	126.45	1745.62	1301.08	1737.33	28172
12	932.00	561.25	561.58	162.93	2246.32	1333.64	1894.89	36244
13	930.00	686.25	686.85	199.47	2747.40	1309.76	1996.01	44316
14	928.00	811.25	812.24	236.03	3248.94	1261.84	2073.09	52388
15	926.00	936.25	937.76	272.57	3751.02	1215.90	2152.15	60460
16	924.00	1061.25	1063.43	309.12	4253.70	1188.68	2249.93	68532
17	922.00	1186.25	1189.26	345.67	4757.06	1187.32	2373.57	76604
18	920.00	1311.25	1315.28	382.21	5261.13	1210.59	2521.84	84676
19	918.00	1436.25	1441.50	418.76	5765.99	1251.19	2687.44	92749
20	916.00	1561.25	1567.92	457.90	6271.67	1292.87	2854.12	100821
21	914.00	1686.25	1694.55	497.57	6778.21	1332.26	3018.51	108893

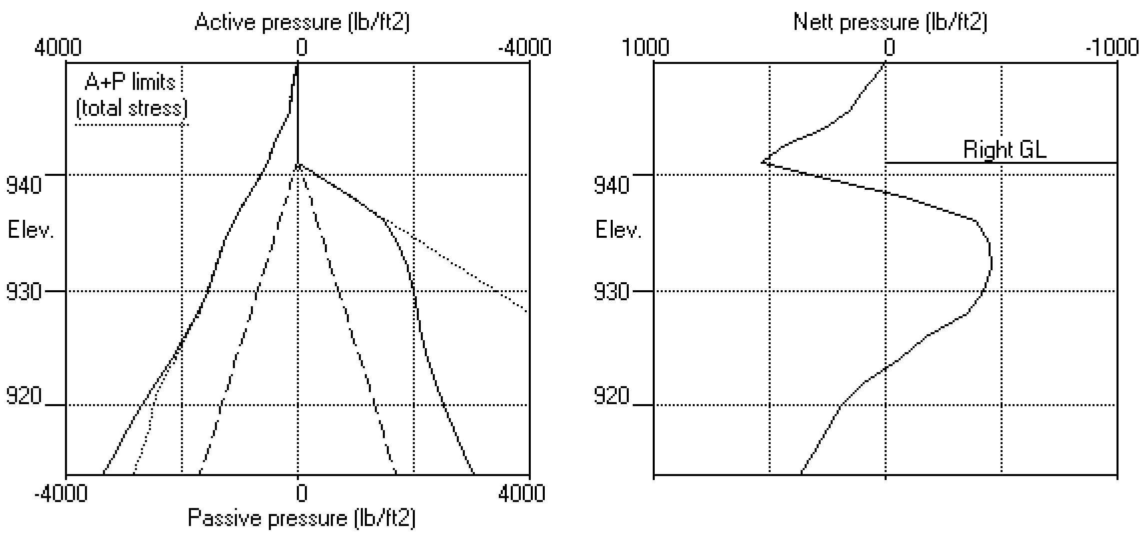
Note: 1571.20a Soil pressure at active limit
931.30p Soil pressure at passive limit

Units: lb,ft

Stage No.6 Apply water pressure profile no.1



Stage No.6 Apply water pressure profile no.1



Units: lb,ft

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 914.00		**Toe elev. for FoS = 2.000**		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	949.65	947.00	Cant.	8.661	917.47	942.00	5.00	L to R
2	949.65	947.00		No analysis at this stage				
3	949.65	947.00		No analysis at this stage				
4	949.65	947.00	Cant.	4.583	915.74	940.97	6.03	L to R
5	949.65	940.98	Cant.	2.389	916.00	918.58	22.40	L to R
6	949.65	940.98	Cant.	2.106	915.80	915.42	25.56	L to R

Units: lb,ft

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum (ft)	Displacement minimum (ft)	Bending moment maximum (lb.ft/ft)	Bending moment minimum (lb.ft/ft)	Shear force maximum (lb/ft)	Shear force minimum (lb/ft)
1	949.65	0.108	0.000	0.0	0.0	0.0	0.0
2	948.00	0.099	0.000	47.1	0.0	51.5	0.0
3	947.00	0.094	0.000	139.9	0.0	133.7	0.0
4	945.50	0.086	0.000	517.6	0.0	330.1	0.0
5	944.00	0.079	0.000	1267.2	0.0	653.1	0.0
6	942.49	0.071	0.000	2649.5	0.0	1183.1	0.0
7	940.98	0.063	0.000	4988.5	0.0	1916.0	0.0
8	939.49	0.056	0.000	8335.1	0.0	2477.7	0.0
9	938.00	0.049	0.000	12165.6	0.0	2580.1	0.0
10	936.00	0.040	0.000	17425.1	0.0	2120.0	-43.5
11	934.00	0.032	0.000	20889.7	0.0	1287.3	-110.5
12	932.00	0.025	0.000	22743.0	0.0	377.7	-148.6
13	930.00	0.019	0.000	22540.1	0.0	0.0	-507.0
14	928.00	0.015	0.000	20828.2	0.0	0.0	-1284.0
15	926.00	0.012	0.000	17580.9	0.0	0.0	-1805.6
16	924.00	0.009	0.000	13627.6	0.0	0.0	-2031.4
17	922.00	0.008	0.000	9538.5	0.0	0.0	-1993.3
18	920.00	0.007	0.000	5746.5	0.0	0.0	-1703.2
19	918.00	0.006	0.000	2735.1	0.0	0.0	-1252.6
20	916.00	0.005	0.000	742.8	0.0	0.0	-684.7
21	914.00	0.005	0.000	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

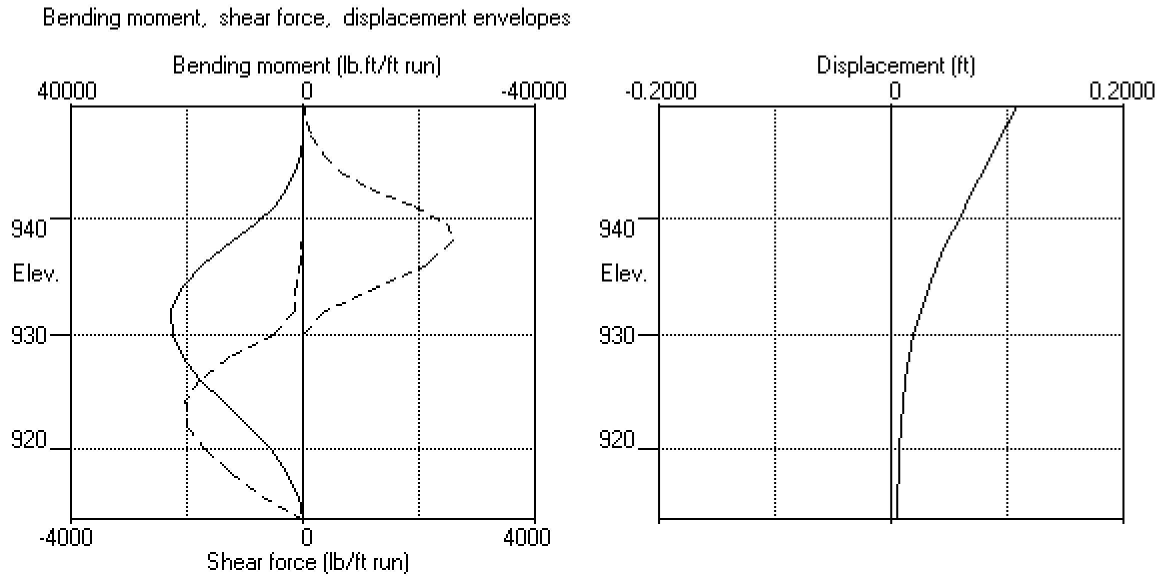
Stage no.	Bending moment maximum (lb.ft/ft)	elev.	Bending moment minimum (lb.ft/ft)	elev.	Shear force maximum (lb/ft)	elev.	Shear force minimum (lb/ft)	elev.
1	2004.3	938.00	-0.0	914.00	275.7	944.00	-160.1	930.00
2	No calculation at this stage							
3	No calculation at this stage							
4	3075.9	932.00	0.0	949.65	230.0	940.98	-250.8	924.00
5	18790.9	932.00	0.0	949.65	2108.1	939.49	-1636.4	924.00
6	22743.0	932.00	0.0	949.65	2580.1	938.00	-2031.4	924.00

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum ft	elev.	minimum ft	elev.	Stage description
1	0.007	949.65	0.000	949.65	Excav. to elev. 947.00 on RIGHT side
2	No calculation at this stage				Apply surcharge no.1 at elev. 948.00
3	No calculation at this stage				Apply surcharge no.2 at elev. 948.00
4	0.021	949.65	0.000	949.65	Apply surcharge no.3 at elev. 948.00
5	0.086	949.65	0.000	949.65	Excav. to elev. 940.98 on RIGHT side
6	0.108	949.65	0.000	949.65	Apply water pressure profile no.1

Units: lb,ft


Bending moment, shear force, displacement envelopes
Bending moment (lb.ft/ft run)
40000
0
-40000
940
Elev.
930
920
-4000
0
4000
Shear force (lb/ft run)
Displacement (ft)
-0.2000
0
0.2000
940
Elev.
930
920

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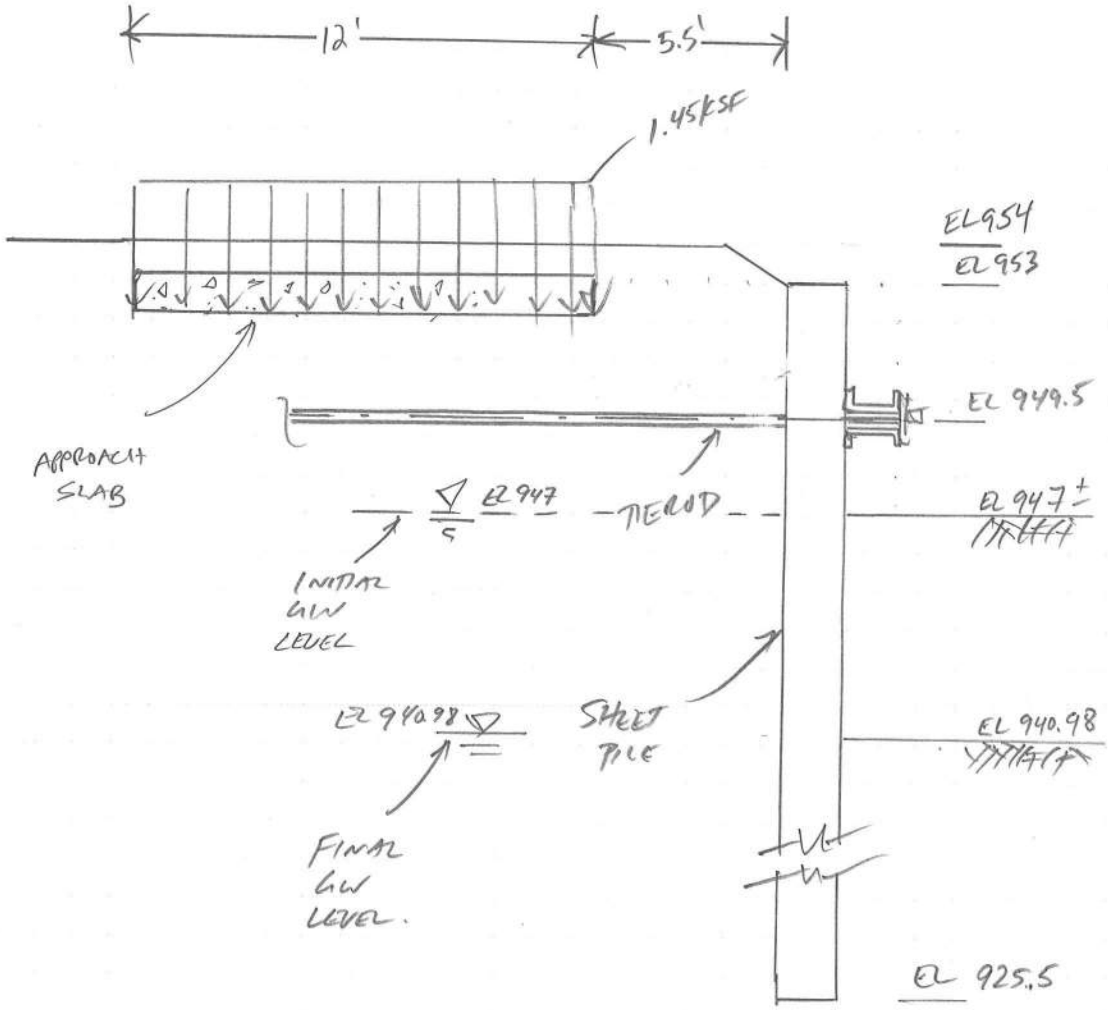


DESIGN SECTION 2

Units: lb,ft

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Left side	Soil types: Right side
1	953.00	1 FILL/SILT/SAND	1 FILL/SILT/SAND

SOIL PROPERTIES

-- Soil type -- No. Description (Datum elev.)	Bulk density lb/ft3	Young's Modulus Eh,lb/ft2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion lb/ft2 (dc/dy)
1 FILL/SILT/-SAND	125.0	0 (40000)	0.500	NC (0.330)	0.292 (0.000)	4.000 (0.000)	

GROUND WATER CONDITIONS

Density of water = 62.50 lb/ft3

	Left side	Right side
Initial water table elevation	947.00	947.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side Point no.	Elev. ft	Piezo elev. ft	Water press. lb/ft2	Right side Point no.	Elev. ft	Piezo elev. ft	Water press. lb/ft2
1	1	940.98	940.98	0.0	1	940.98	940.98	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 925.00
Maximum finite element length = 1.60 ft
Youngs modulus of wall E = 4.1760E+09 lb/ft2
Moment of inertia of wall I = 0.017400 ft4/ft run
E.I = 7.2662E+07 lb.ft2/ft run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing ft	Cross-section area sq.ft	Youngs modulus lb/ft2	Free length ft	Inclin -ation (degs)	Pre-stress /prop lb	Strut or Anchor	Allow tension ?	L/R
1	949.65	1.00	1.000000	4.176E+09	1.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge lb/ft2 Near edge	Surcharge lb/ft2 Far edge	Equiv. soil type	Partial factor/ Category
1	953.00	1.00(L)	100.00	22.00	125.00	=	0	N/A
2	952.25	5.50(L)	100.00	12.00	1450.00	=	0	N/A

Note: L = Left side, R = Right side

CONSTRUCTION STAGES

```
Construction   Stage description
  stage no.    --------------------------------------------------------
      1        Excavate to elevation 947.00 on RIGHT side
      2        Apply surcharge no.1 at elevation 953.00
      3        Apply surcharge no.2 at elevation 952.25
      4        Install strut or anchor no.1 at elevation 949.65
      5        Excavate to elevation 940.98 on RIGHT side
      6        Apply water pressure profile no.1
```

FACTORS OF SAFETY and ANALYSIS OPTIONS

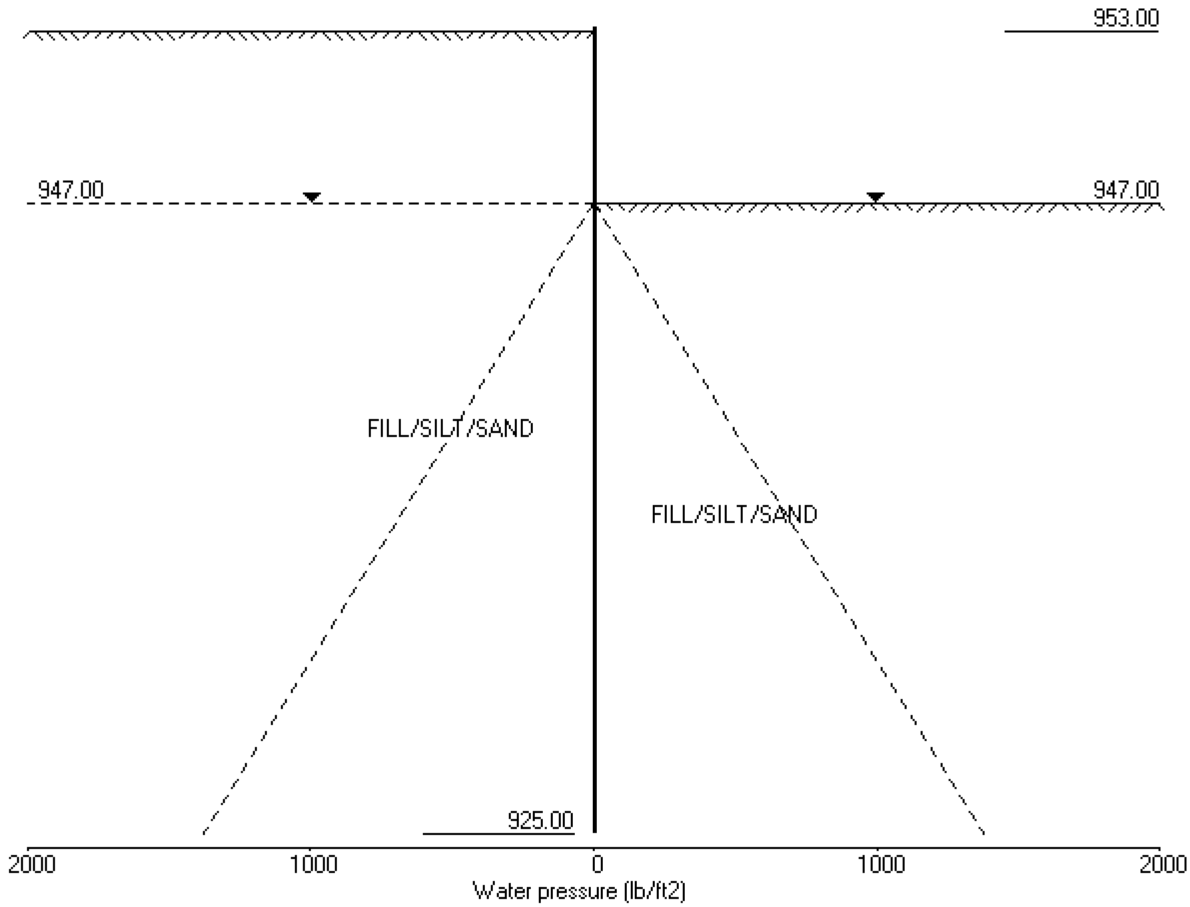
```
 Stability analysis:
  Method of analysis  -  CP2
  Factor on passive for calculating wall depth = 2.00
  Active limit pressures calculated by Wedge Stability

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   0.00 lb/ft3
  Maximum depth of water filled tension crack  =   0.00 ft

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 27.50 ft

 Boundary conditions:
  Length of wall (normal to plane of analysis) = 1000.00 ft

  Width of excavation on Left  side of wall  = 100.00 ft
  Width of excavation on Right side of wall  = 100.00 ft

  Distance to rigid boundary on Left side  = 100.00 ft
  Distance to rigid boundary on Right side = 100.00 ft
```

OUTPUT OPTIONS

```
 Stage ------ Stage description ----------- ------- Output options -------
  no.                                       Displacement   Active,  Graph.
                                            Bending mom.   Passive  output
                                            Shear force   pressures
    1 Excav. to elev. 947.00 on RIGHT side      Yes          Yes     Yes
    2 Apply surcharge no.1 at elev. 953.00      Yes          Yes     Yes
    3 Apply surcharge no.2 at elev. 952.25      Yes          Yes     Yes
    4 Install prop no.1 at elev. 949.65         Yes          Yes     Yes
    5 Excav. to elev. 940.98 on RIGHT side      Yes          Yes     Yes
    6 Apply water pressure profile no.1         Yes          Yes     Yes
    * Summary output                            Yes           -      Yes
```

Units: lb,ft

Stage No.1 Excav. to elev. 947.00 on RIGHT side



Units: lb,ft

Stage No. 1 Excavate to elevation 947.00 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = 925.00 Factor of Safety	FoS for toe elev. = 925.00 Moment equilib. at elev.	Toe elev. for FoS = 2.000 Toe elev.	Toe elev. for FoS = 2.000 Wall Penetr -ation	Direction of failure
1	953.00	947.00	Cant.	4.017	927.18	935.59	11.41	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	953.00	0.00	0.028	1.58E-03	0.0	0.0	
2	952.25	26.99	0.027	1.58E-03	10.1	2.5	
3	950.95	74.41	0.025	1.58E-03	76.0	51.9	
4	949.65	121.87	0.023	1.57E-03	203.6	226.9	
5	948.33	170.21	0.020	1.56E-03	397.1	617.9	
6	947.00	218.17	0.018	1.55E-03	654.4	1307.5	
7	945.50	72.77	0.016	1.51E-03	872.6	2525.0	
8	944.00	-33.45	0.014	1.44E-03	902.1	3908.5	
9	942.49	-109.61	0.012	1.35E-03	794.1	5225.1	
10	940.98	-158.88	0.010	1.23E-03	591.4	6291.9	
11	940.09	-177.24	0.009	1.15E-03	441.8	6753.8	
12	939.20	-189.05	0.008	1.06E-03	278.8	7075.3	
13	937.60	-197.46	0.006	9.09E-04	-30.4	7270.5	
14	936.00	-194.53	0.005	7.52E-04	-344.0	6960.3	
15	934.40	-153.72	0.004	6.06E-04	-622.6	6288.8	
16	932.80	-74.40	0.003	4.81E-04	-805.1	5095.9	
17	931.20	0.03	0.002	3.84E-04	-864.6	3712.5	
18	929.60	70.50	0.002	3.17E-04	-808.1	2329.1	
19	928.00	140.74	0.001	2.79E-04	-639.1	1126.3	
20	926.50	210.98	0.001	2.64E-04	-375.3	325.8	
21	925.00	289.48	0.000	2.61E-04	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. lb/ft2	Effective stresses Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Effective stresses Passive limit lb/ft2	Effective stresses Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	519
2	952.25	0.00	93.75	26.99	375.00	26.99	26.99a	3116
3	950.95	0.00	256.25	74.41	1025.00	74.41	74.41a	8518
4	949.65	0.00	418.75	121.87	1675.00	121.87	121.87a	13919

(continued)

Stage No.1 Excavate to elevation 947.00 on RIGHT side

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	948.33	0.00	584.37	170.21	2337.50	170.21	170.21a	19425
6	947.00	0.00	750.00	218.17	3000.00	218.17	218.17a	24930
7	945.50	93.75	843.75	245.18	3375.00	245.18	338.93a	31162
8	944.00	187.50	937.50	272.60	3750.00	272.60	460.10a	37395
9	942.49	281.87	1031.87	300.20	4127.50	300.20	582.07a	43669
10	940.98	376.25	1126.25	327.77	4505.00	327.77	704.02a	49943
11	940.09	431.87	1181.87	344.07	4727.50	344.07	775.95a	53641
12	939.20	487.50	1237.50	360.37	4950.00	360.37	847.87a	57339
13	937.60	587.50	1337.50	389.58	5350.00	389.58	977.08a	63987
14	936.00	687.50	1437.50	418.83	5750.00	418.83	1106.33a	70635
15	934.40	787.50	1537.50	448.08	6150.00	480.08	1267.58	77283
16	932.80	887.50	1637.50	477.32	6550.00	578.01	1465.51	83930
17	931.20	987.50	1737.50	506.57	6950.00	671.31	1658.81	90578
18	929.60	1087.50	1837.50	535.82	7350.00	761.05	1848.55	97226
19	928.00	1187.50	1937.50	565.06	7750.00	849.57	2037.07	103874
20	926.50	1281.25	2031.25	595.34	8125.00	934.05	2215.30	110107
21	925.00	1375.00	2125.00	625.84	8500.00	1022.13	2397.13	116339

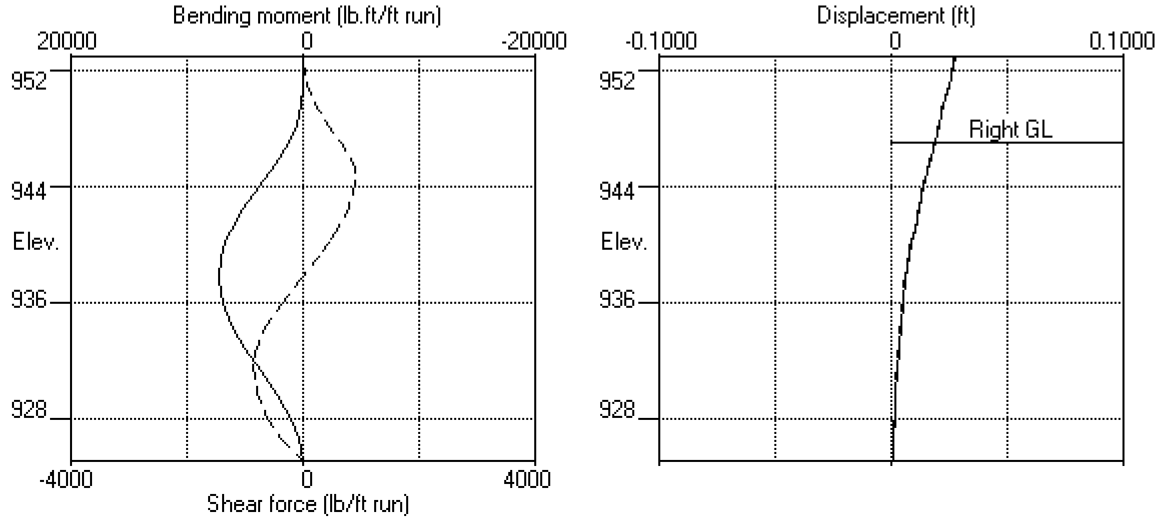
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	952.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	950.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	948.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	1244
7	945.50	93.75	93.75	25.88	375.00	172.41	266.16	7462
8	944.00	187.50	187.51	53.57	750.03	306.04	493.54	14925
9	942.49	281.87	281.90	81.28	1127.62	409.81	691.68	22437
10	940.98	376.25	376.32	108.88	1505.28	486.66	862.91	29949
11	940.09	431.87	431.98	125.16	1727.92	521.31	953.19	34377
12	939.20	487.50	487.65	141.47	1950.60	549.42	1036.92	38804
13	937.60	587.50	587.76	170.67	2351.05	587.04	1174.54	46764
14	936.00	687.50	687.92	199.92	2751.67	613.36	1300.86	54724
15	934.40	787.50	788.12	229.17	3152.50	633.80	1421.30	62684
16	932.80	887.50	888.39	258.42	3553.56	652.41	1539.91	70644
17	931.20	987.50	988.72	287.67	3954.88	671.28	1658.78	78604
18	929.60	1087.50	1089.12	316.92	4356.47	690.55	1778.05	86563
19	928.00	1187.50	1189.59	346.17	4758.37	708.83	1896.33	94523
20	926.50	1281.25	1283.86	376.41	5135.44	723.07	2004.32	101986
21	925.00	1375.00	1378.20	407.09	5512.81	732.65	2107.65	109448

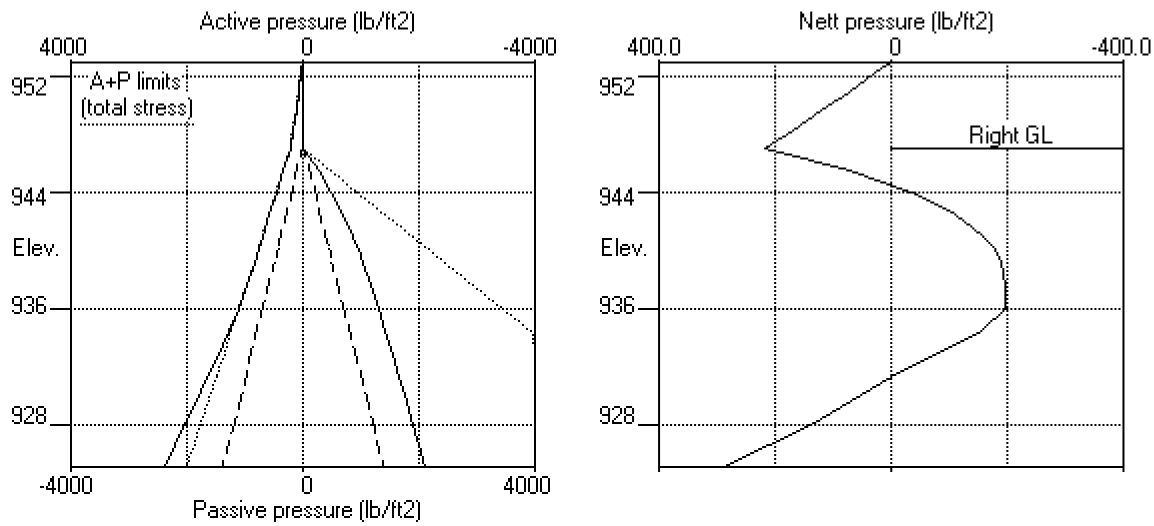
Note: 1106.33a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: lb,ft

Stage No.1 Excav. to elev. 947.00 on RIGHT side

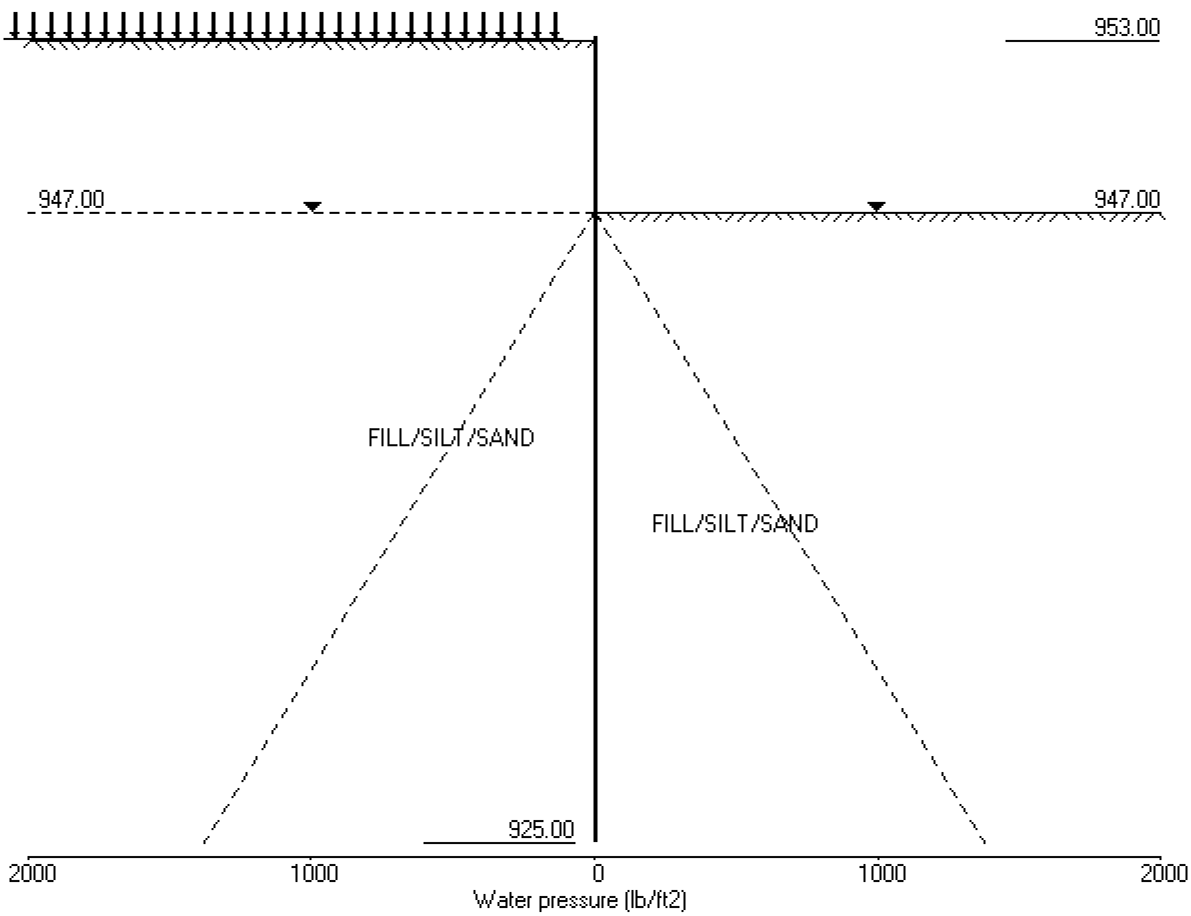


Stage No.1 Excav. to elev. 947.00 on RIGHT side



Units: lb,ft

Stage No.2 Apply surcharge no.1 at elev. 953.00



Units: lb,ft

Stage No. 2 Apply surcharge no.1 at elevation 953.00

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 925.00		Toe elev. for FoS = 2.000		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
2	953.00	947.00	Cant.	3.575	927.14	934.18	12.82	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	953.00	0.00	0.034	1.93E-03	0.0	0.0	
2	952.25	31.48	0.033	1.93E-03	11.8	3.0	
3	950.95	99.91	0.030	1.93E-03	97.2	64.2	
4	949.65	154.83	0.028	1.93E-03	262.8	290.4	
5	948.33	201.44	0.025	1.92E-03	498.8	788.2	
6	947.00	254.47	0.023	1.89E-03	800.9	1641.5	
7	945.50	83.00	0.020	1.84E-03	1054.0	3119.9	
8	944.00	-45.73	0.017	1.76E-03	1081.9	4786.0	
9	942.49	-135.49	0.015	1.65E-03	945.1	6360.1	
10	940.98	-192.50	0.012	1.50E-03	697.5	7625.2	
11	940.09	-213.19	0.011	1.40E-03	516.9	8168.2	
12	939.20	-225.79	0.010	1.30E-03	321.6	8542.3	
13	937.60	-232.64	0.008	1.11E-03	-45.2	8758.9	
14	936.00	-225.41	0.006	9.27E-04	-411.6	8380.0	
15	934.40	-187.31	0.005	7.52E-04	-741.8	7588.8	
16	932.80	-92.30	0.004	6.00E-04	-965.5	6161.1	
17	931.20	-2.49	0.003	4.83E-04	-1041.3	4497.2	
18	929.60	83.24	0.002	4.02E-04	-976.7	2826.7	
19	928.00	169.39	0.001	3.56E-04	-774.6	1369.3	
20	926.50	256.12	0.001	3.38E-04	-455.5	397.0	
21	925.00	351.16	0.000	3.34E-04	-0.0	0.0	

		LEFT side						
			Effective stresses					
Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	511
2	952.25	0.00	106.76	31.48	427.04	31.48	31.48a	3066
3	950.95	0.00	313.74	99.91	1254.95	99.91	99.91a	8379
4	949.65	0.00	498.69	154.83	1994.75	154.83	154.83a	13693

(continued)

Stage No.2 Apply surcharge no.1 at elevation 953.00

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	948.33	0.00	675.88	201.44	2703.54	201.44	201.44a	19109
6	947.00	0.00	848.04	254.47	3392.17	254.47	254.47a	24525
7	945.50	93.75	946.07	282.58	3784.28	282.58	376.33a	30656
8	944.00	187.50	1042.15	307.53	4168.61	307.53	495.03a	36787
9	942.49	281.87	1137.59	335.07	4550.37	335.07	616.94a	42959
10	940.98	376.25	1232.11	362.63	4928.46	362.63	738.88a	49131
11	940.09	431.87	1287.49	378.83	5149.97	378.83	810.70a	52769
12	939.20	487.50	1342.67	395.10	5370.68	395.10	882.60a	56407
13	937.60	587.50	1441.44	424.30	5765.75	424.30	1011.80a	62947
14	936.00	687.50	1539.77	453.50	6159.07	453.50	1141.00a	69486
15	934.40	787.50	1637.77	482.71	6551.07	505.98	1293.48	76026
16	932.80	887.50	1735.52	511.92	6942.08	612.70	1500.20	82566
17	931.20	987.50	1833.09	541.12	7332.37	714.05	1701.55	89106
18	929.60	1087.50	1930.54	570.33	7722.17	811.34	1898.84	95646
19	928.00	1187.50	2027.92	599.53	8111.66	907.44	2094.94	102186
20	926.50	1281.25	2119.16	629.72	8476.66	999.61	2280.86	108317
21	925.00	1375.00	2210.40	659.95	8841.60	1094.11	2469.11	114448

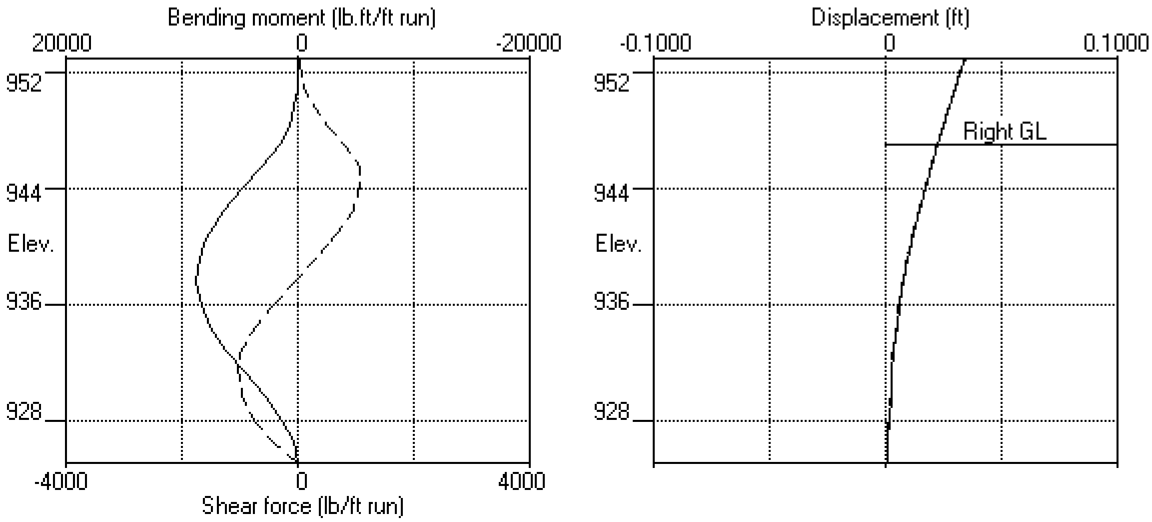
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	952.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	950.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	948.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	1207
7	945.50	93.75	93.75	25.88	375.00	199.59	293.34	7242
8	944.00	187.50	187.51	53.57	750.03	353.26	540.76	14483
9	942.49	281.87	281.90	81.28	1127.62	470.56	752.43	21773
10	940.98	376.25	376.32	108.88	1505.28	555.14	931.39	29063
11	940.09	431.87	431.98	125.16	1727.92	592.02	1023.89	33359
12	939.20	487.50	487.65	141.47	1950.60	620.89	1108.39	37656
13	937.60	587.50	587.76	170.67	2351.05	656.94	1244.44	45380
14	936.00	687.50	687.92	199.92	2751.67	678.91	1366.41	53105
15	934.40	787.50	788.12	229.17	3152.50	693.29	1480.79	60829
16	932.80	887.50	888.39	258.42	3553.56	705.00	1592.50	68553
17	931.20	987.50	988.72	287.67	3954.88	716.53	1704.03	76278
18	929.60	1087.50	1089.12	316.92	4356.47	728.10	1815.60	84002
19	928.00	1187.50	1189.59	346.17	4758.37	738.05	1925.55	91726
20	926.50	1281.25	1283.86	376.41	5135.44	743.49	2024.74	98968
21	925.00	1375.00	1378.20	407.09	5512.81	742.94	2117.94	106209

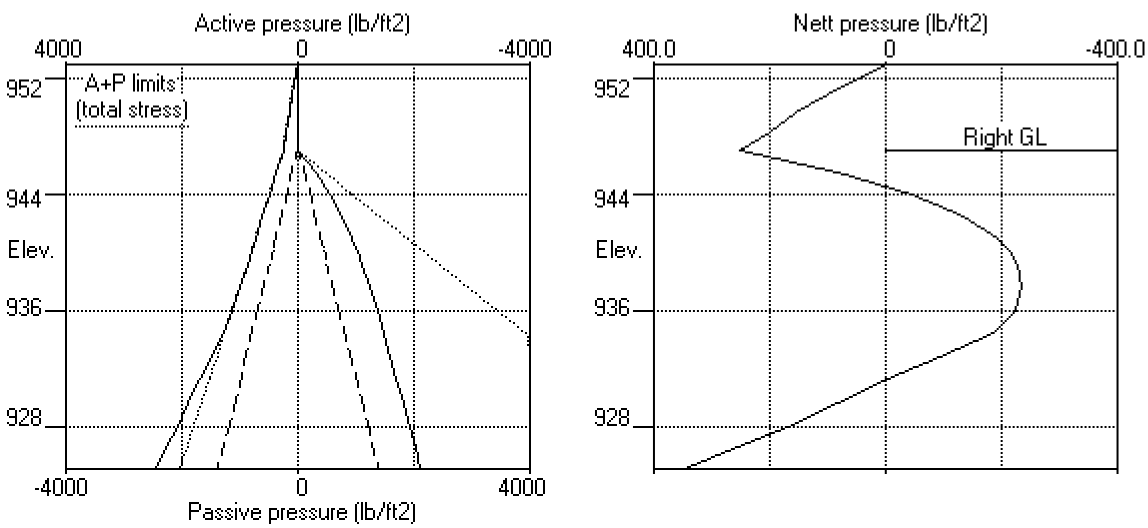
Note: 1141.00a Soil pressure at active limit
123.45p Soil pressure at passive limit

```
GEI CONSULTANTS, INC.                                          | Sheet No.
Program: WALLAP  Version 6.06  Revision A52.B71.R55            | Job No.
                                Licensed from GEOSOLVE         | Made by :   JLC
Data filename/Run ID: Section_2_REV_July_Wale_2022             |
MassDOT RR                                                     | Date: 6-07-2022
79.90                                                          | Checked :
-----------------------------------------------------------------------------
                                                       Units: lb,ft
```

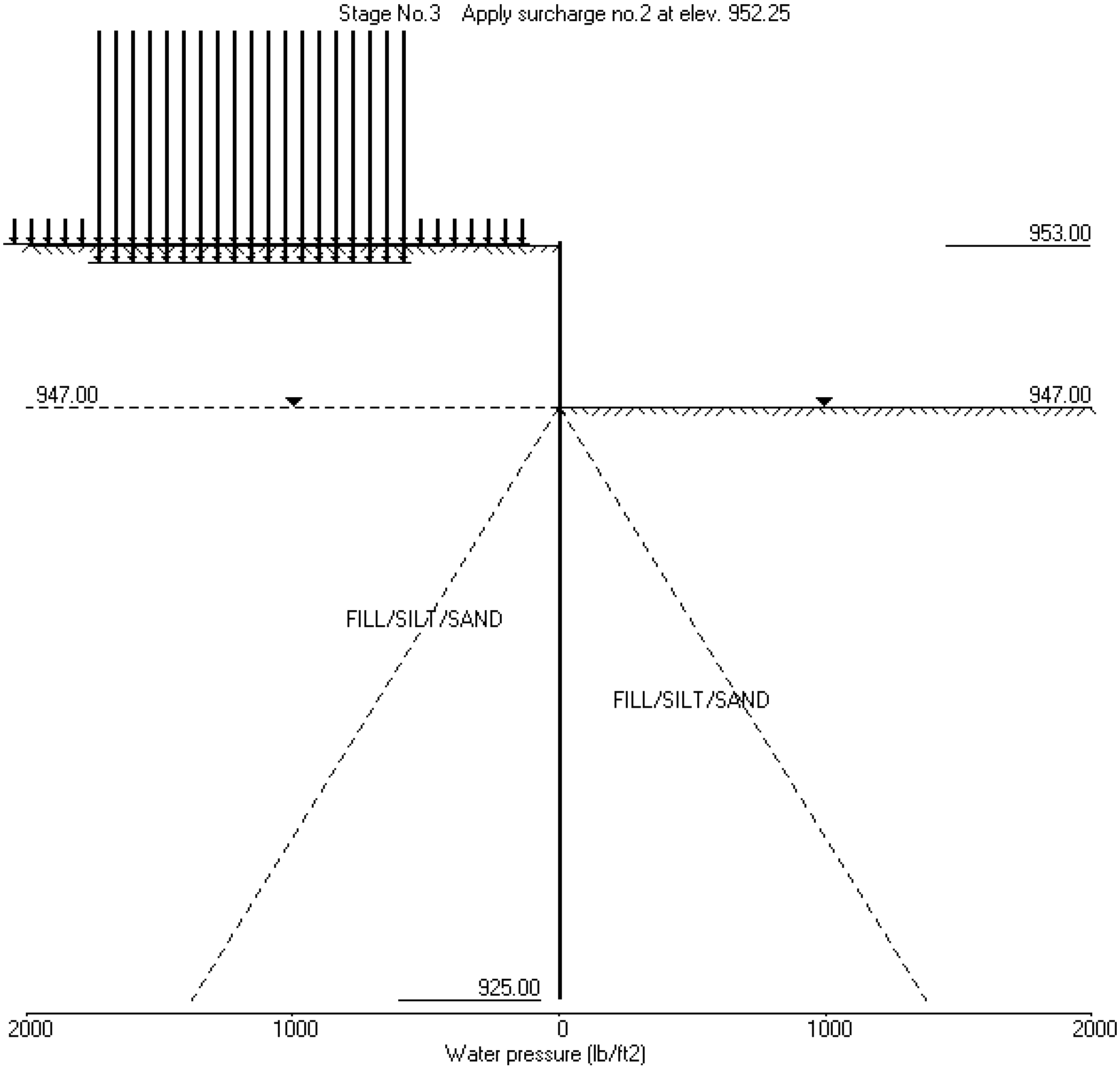
Stage No.2 Apply surcharge no.1 at elev. 953.00



Stage No.2 Apply surcharge no.1 at elev. 953.00



Units: lb,ft


Stage No.3 Apply surcharge no.2 at elev. 952.25
953.00
947.00
947.00
FILL/SILT/SAND
FILL/SILT/SAND
925.00
2000
1000
0
1000
2000
Water pressure (lb/ft2)

Units: lb,ft

Stage No. 3 Apply surcharge no.2 at elevation 952.25

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = 925.00: Factor of Safety	FoS for toe elev. = 925.00: Moment equilib. at elev.	Toe elev. for FoS = 2.000: Toe elev.	Toe elev. for FoS = 2.000: Wall Penetr -ation	Direction of failure
3	953.00	947.00	Cant.	2.122	926.55	926.36	20.64	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	953.00	0.00	0.068	3.48E-03	0.0	0.0	
2	952.25	33.62	0.066	3.48E-03	12.6	3.2	
3	950.95	106.74	0.061	3.48E-03	103.8	68.5	
4	949.65	161.90	0.057	3.48E-03	278.5	309.3	
5	948.33	239.74	0.052	3.47E-03	544.5	843.1	
6	947.00	429.72	0.047	3.44E-03	988.1	1830.7	
7	945.50	231.97	0.042	3.38E-03	1484.3	3831.3	
8	944.00	-11.72	0.037	3.28E-03	1649.5	6310.5	
9	942.49	-184.45	0.033	3.12E-03	1501.4	8782.0	
10	940.98	-231.13	0.028	2.92E-03	1187.6	10858.0	
11	940.09	-263.26	0.025	2.78E-03	967.6	11823.4	
12	939.20	-332.90	0.023	2.63E-03	702.3	12573.3	
13	937.60	-352.91	0.019	2.34E-03	153.7	13260.2	
14	936.00	-330.53	0.015	2.06E-03	-393.1	13047.0	
15	934.40	-293.29	0.012	1.78E-03	-892.1	12138.2	
16	932.80	-228.88	0.010	1.53E-03	-1309.8	10303.1	
17	931.20	-118.17	0.007	1.33E-03	-1587.5	7898.8	
18	929.60	55.73	0.005	1.19E-03	-1637.4	5216.2	
19	928.00	247.61	0.004	1.10E-03	-1394.8	2678.9	
20	926.50	415.58	0.002	1.06E-03	-897.4	901.7	
21	925.00	780.90	0.000	1.05E-03	-0.0	-0.0	

		LEFT side						
			Effective stresses				Total	Coeff. of
Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	earth pressure lb/ft2	subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	463
2	952.25	0.00	106.76	33.62	427.04	33.62	33.62a	2779
3	950.95	0.00	321.10	106.74	1284.39	106.74	106.74a	7596
4	949.65	0.00	547.66	161.90	2190.66	161.90	161.90a	12414

(continued)

Stage No.3 Apply surcharge no.2 at elevation 952.25

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
5	948.33	0.00	804.95	239.74	3219.79	239.74	239.74a	17324
6	947.00	0.00	1075.38	429.72	4301.50	429.72	429.72a	22233
7	945.50	93.75	1282.66	575.92	5130.63	575.92	669.67a	27792
8	944.00	187.50	1472.06	600.88	5888.24	600.88	788.38a	33350
9	942.49	281.87	1641.07	632.43	6564.28	632.43	914.30a	38946
10	940.98	376.25	1789.62	730.08	7158.48	730.08	1106.33a	44541
11	940.09	431.87	1868.79	758.20	7475.15	758.20	1190.08a	47839
12	939.20	487.50	1942.57	732.69	7770.30	732.69	1220.19a	51137
13	937.60	587.50	2063.78	757.64	8255.14	757.64	1345.14a	57066
14	936.00	687.50	2173.20	790.25	8692.81	790.25	1477.75a	62995
15	934.40	787.50	2273.71	813.02	9094.84	813.02	1600.52a	68924
16	932.80	887.50	2367.61	846.25	9470.44	846.25	1733.75a	74852
17	931.20	987.50	2456.70	913.84	9826.78	913.84	1901.34a	80781
18	929.60	1087.50	2542.36	1033.94	10169.42	1033.94	2121.44a	86710
19	928.00	1187.50	2625.64	1159.28	10502.57	1159.28	2346.78a	92639
20	926.50	1281.25	2702.28	1005.96	10809.13	1249.61	2530.86	98198
21	925.00	1375.00	2778.04	855.08	11112.15	1460.68	2835.68	1319549

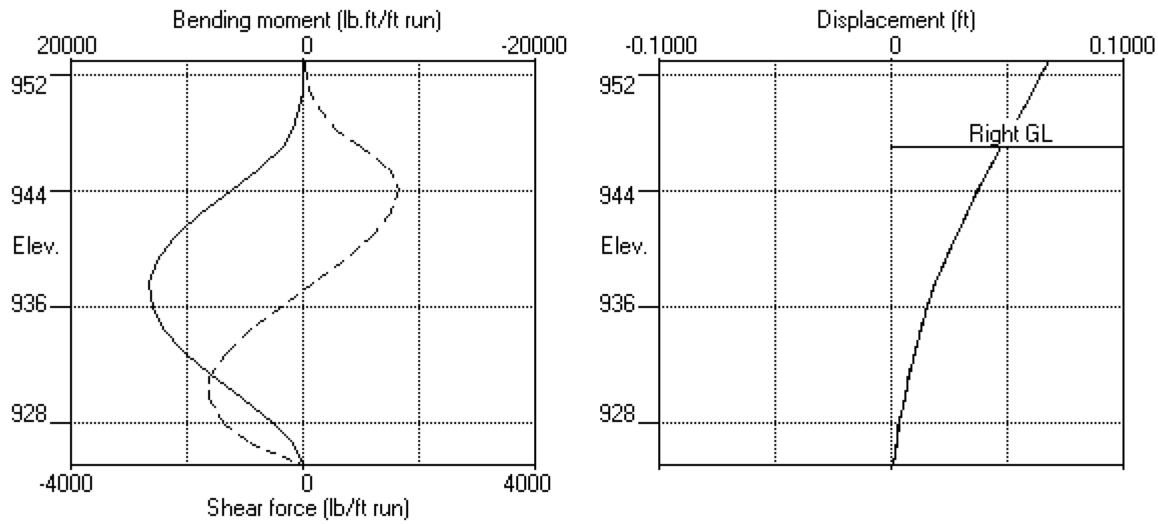
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	952.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	950.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	948.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	1068
7	945.50	93.75	93.75	25.88	375.00	343.95	437.70	6407
8	944.00	187.50	187.51	53.57	750.03	612.60	800.10	12814
9	942.49	281.87	281.90	81.28	1127.62	816.88	1098.76	19264
10	940.98	376.25	376.32	108.88	1505.28	961.21	1337.46	25713
11	940.09	431.87	431.98	125.16	1727.92	1021.46	1453.34	29515
12	939.20	487.50	487.65	141.47	1950.60	1065.59	1553.09	33316
13	937.60	587.50	587.76	170.67	2351.05	1110.55	1698.05	40150
14	936.00	687.50	687.92	199.92	2751.67	1120.78	1808.28	46984
15	934.40	787.50	788.12	229.17	3152.50	1106.31	1893.81	53818
16	932.80	887.50	888.39	258.42	3553.56	1075.13	1962.63	60652
17	931.20	987.50	988.72	287.67	3954.88	1032.01	2019.51	67486
18	929.60	1087.50	1089.12	316.92	4356.47	978.20	2065.70	74320
19	928.00	1187.50	1189.59	346.17	4758.37	911.67	2099.17	81155
20	926.50	1281.25	1283.86	376.41	5135.44	834.03	2115.28	87561
21	925.00	1375.00	1378.20	407.09	5512.81	679.78	2054.78	1163151

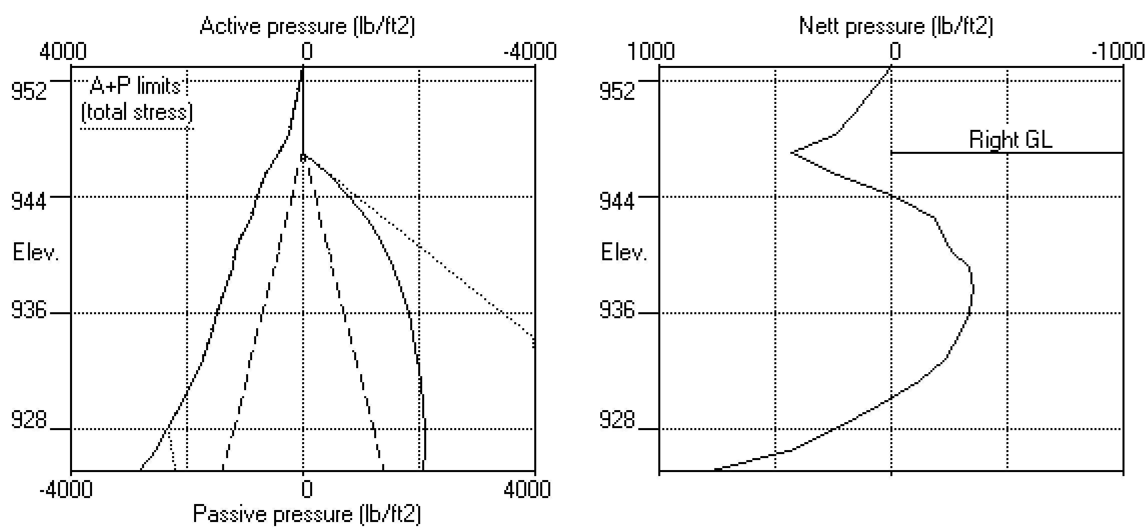
Note: 2346.78a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: lb,ft

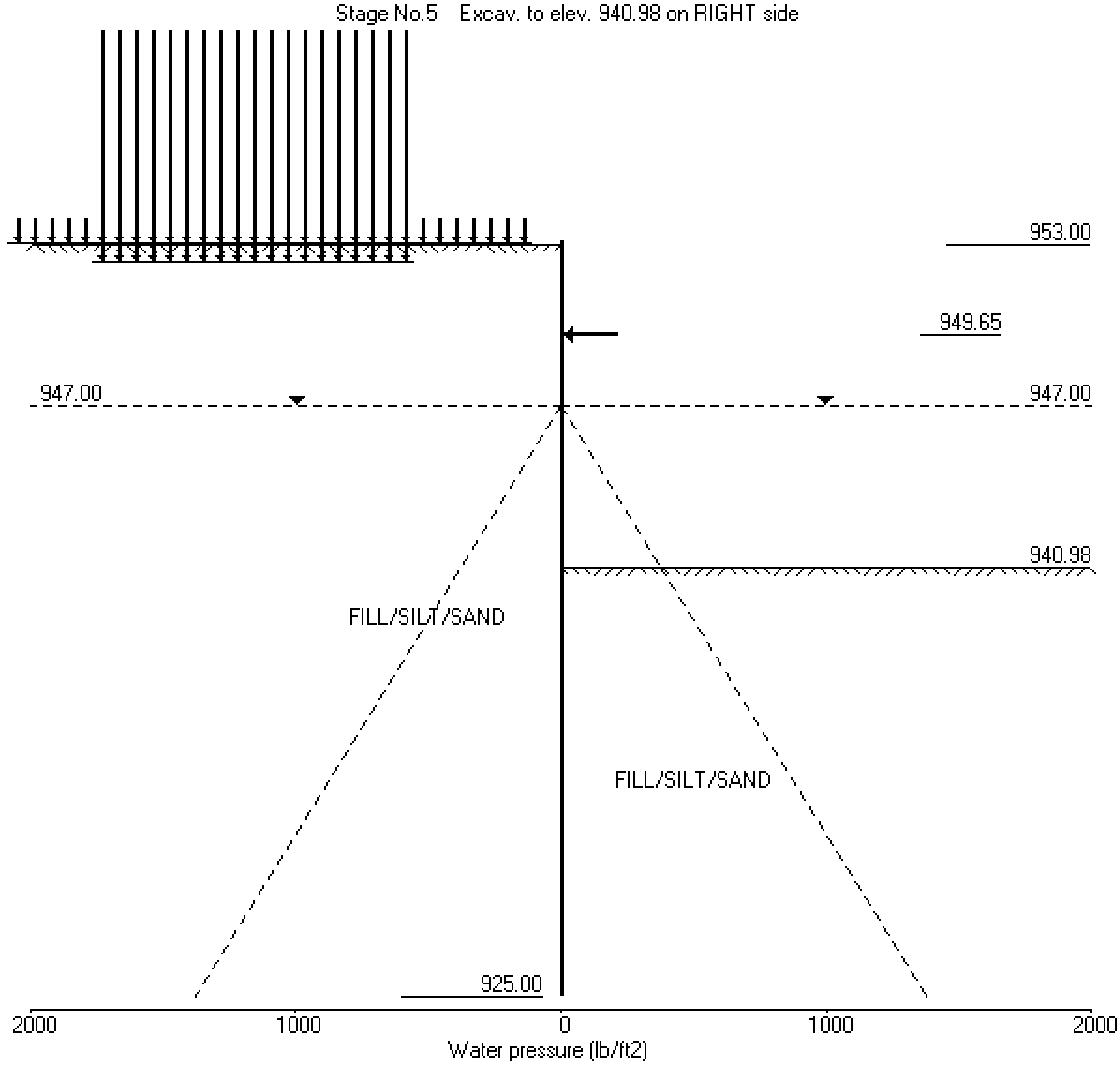
Stage No.3 Apply surcharge no.2 at elev. 952.25



Stage No.3 Apply surcharge no.2 at elev. 952.25



Units: lb,ft


Stage No.5 Excav. to elev. 940.98 on RIGHT side
953.00
949.65
947.00
947.00
940.98
FILL/SILT/SAND
FILL/SILT/SAND
925.00
2000
1000
0
1000
2000
Water pressure (lb/ft2)

Units: lb,ft

Stage No. 5 Excavate to elevation 940.98 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = 925.00 Factor of Safety	FoS for toe elev. = 925.00 Moment equilib. at elev.	Toe elev. for FoS = 2.000 Toe elev.	Toe elev. for FoS = 2.000 Wall Penetr -ation	Direction of failure
5	953.00	940.98	949.65	2.331	n/a	927.05	13.93	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	953.00	0.00	0.061	1.15E-03	0.0	0.0	
2	952.25	88.96	0.060	1.15E-03	33.4	3.2	
3	950.95	182.39	0.058	1.15E-03	209.7	142.3	
4	949.65	161.90	0.057	1.15E-03	433.5	584.6	-3575.5
		161.90	0.057	1.15E-03	-3142.0	584.6	
5	948.33	239.74	0.055	1.17E-03	-2875.9	-3413.6	
6	947.00	429.72	0.054	1.27E-03	-2432.4	-6958.1	
7	945.50	575.92	0.052	1.44E-03	-1678.1	-9959.1	
8	944.00	600.88	0.049	1.66E-03	-795.5	-11735.9	
9	942.49	632.43	0.046	1.91E-03	135.6	-12180.4	
10	940.98	730.08	0.043	2.16E-03	1164.3	-11180.6	
11	940.09	535.70	0.041	2.28E-03	1727.6	-9876.6	
12	939.20	287.68	0.039	2.40E-03	2094.0	-8157.5	
13	937.60	-87.43	0.035	2.54E-03	2254.2	-4601.2	
14	936.00	-420.56	0.031	2.60E-03	1847.8	-1148.0	
15	934.40	-446.40	0.027	2.60E-03	1154.2	1413.4	
16	932.80	-421.80	0.023	2.55E-03	459.6	2656.4	
17	931.20	-324.96	0.019	2.49E-03	-137.8	2836.4	
18	929.60	-137.99	0.015	2.44E-03	-508.1	2208.7	
19	928.00	93.62	0.011	2.40E-03	-543.6	1230.3	
20	926.50	78.53	0.007	2.38E-03	-414.5	465.2	
21	925.00	474.16	0.004	2.37E-03	-0.0	0.0	

At elev. 949.65 Prop force = 3575.5 lb/ft run

(continued)

Stage No.5 Excavate to elevation 940.98 on RIGHT side

LEFT side

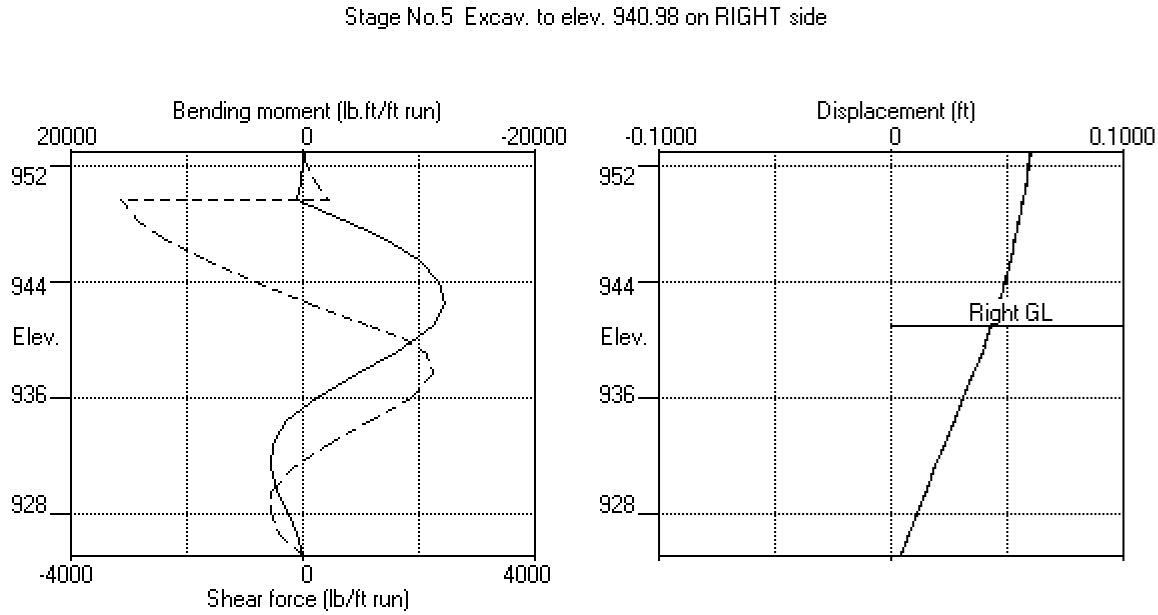
Node no.	Y coord	Water press. lb/ft2	Effective stresses Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	1524
2	952.25	0.00	106.76	33.62	427.04	88.96	88.96	9143
3	950.95	0.00	321.10	106.74	1284.39	182.39	182.39	24990
4	949.65	0.00	547.66	161.90	2190.66	161.90	161.90a	10055
5	948.33	0.00	804.95	239.74	3219.79	239.74	239.74a	14031
6	947.00	0.00	1075.38	429.72	4301.50	429.72	429.72a	18008
7	945.50	93.75	1282.66	575.92	5130.63	575.92	669.67a	22510
8	944.00	187.50	1472.06	600.88	5888.24	600.88	788.38a	27012
9	942.49	281.87	1641.07	632.43	6564.28	632.43	914.30a	31544
10	940.98	376.25	1789.62	730.08	7158.48	730.08	1106.33a	36076
11	940.09	431.87	1868.79	758.20	7475.15	758.20	1190.08a	38748
12	939.20	487.50	1942.57	732.69	7770.30	732.69	1220.19a	41419
13	937.60	587.50	2063.78	757.64	8255.14	757.64	1345.14a	46221
14	936.00	687.50	2173.20	790.25	8692.81	790.25	1477.75a	51023
15	934.40	787.50	2273.71	813.02	9094.84	813.02	1600.52a	55825
16	932.80	887.50	2367.61	846.25	9470.44	846.25	1733.75a	60628
17	931.20	987.50	2456.70	913.84	9826.78	913.84	1901.34a	65430
18	929.60	1087.50	2542.36	1033.94	10169.42	1033.94	2121.44a	70232
19	928.00	1187.50	2625.64	1159.28	10502.57	1159.28	2346.78a	75034
20	926.50	1281.25	2702.28	1005.96	10809.13	1005.96	2287.21a	79536
21	925.00	1375.00	2778.04	855.08	11112.15	1165.16	2540.16	84038

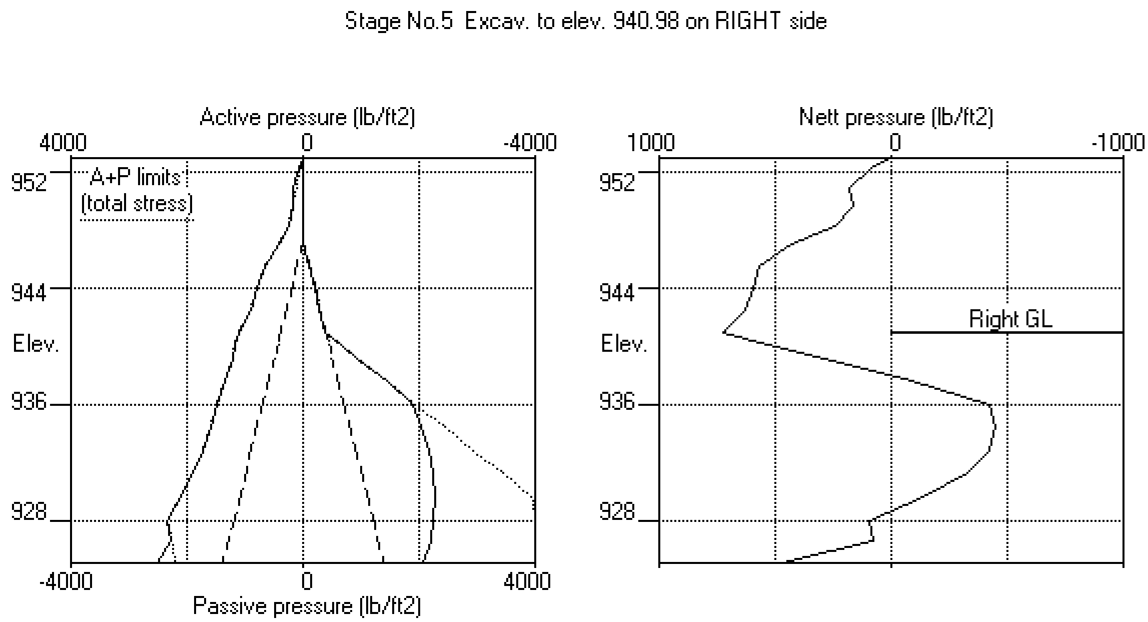
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Effective stresses Vertic -al lb/ft2	Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	952.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	950.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	948.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	945.50	93.75	0.00	0.00	0.00	0.00	93.75	0.0
8	944.00	187.50	0.00	0.00	0.00	0.00	187.50	0.0
9	942.49	281.87	0.00	0.00	0.00	0.00	281.87	0.0
10	940.98	376.25	0.00	0.00	0.00	0.00	376.25	0.0
		376.25	0.00	0.00	0.00	0.00	376.25	521
11	940.09	431.87	55.63	25.86	222.50	222.50	654.38p	3123
12	939.20	487.50	111.25	28.52	445.01	445.01	932.51p	6246
13	937.60	587.50	211.27	64.67	845.07	845.07	1432.57p	11861
14	936.00	687.50	311.31	96.91	1245.24	1210.82	1898.32	17475
15	934.40	787.50	411.39	121.61	1645.54	1259.42	2046.92	23090
16	932.80	887.50	511.51	152.91	2046.04	1268.06	2155.56	28704
17	931.20	987.50	611.69	187.36	2446.77	1238.80	2226.30	34319
18	929.60	1087.50	711.94	210.28	2847.77	1171.93	2259.43	39934
19	928.00	1187.50	812.27	239.52	3249.10	1065.67	2253.17	45548
20	926.50	1281.25	906.42	276.30	3625.66	927.44	2208.69	50812
21	925.00	1375.00	1000.64	304.90	4002.57	691.00	2066.00	56076

Note: 2287.21a Soil pressure at active limit
1432.57p Soil pressure at passive limit

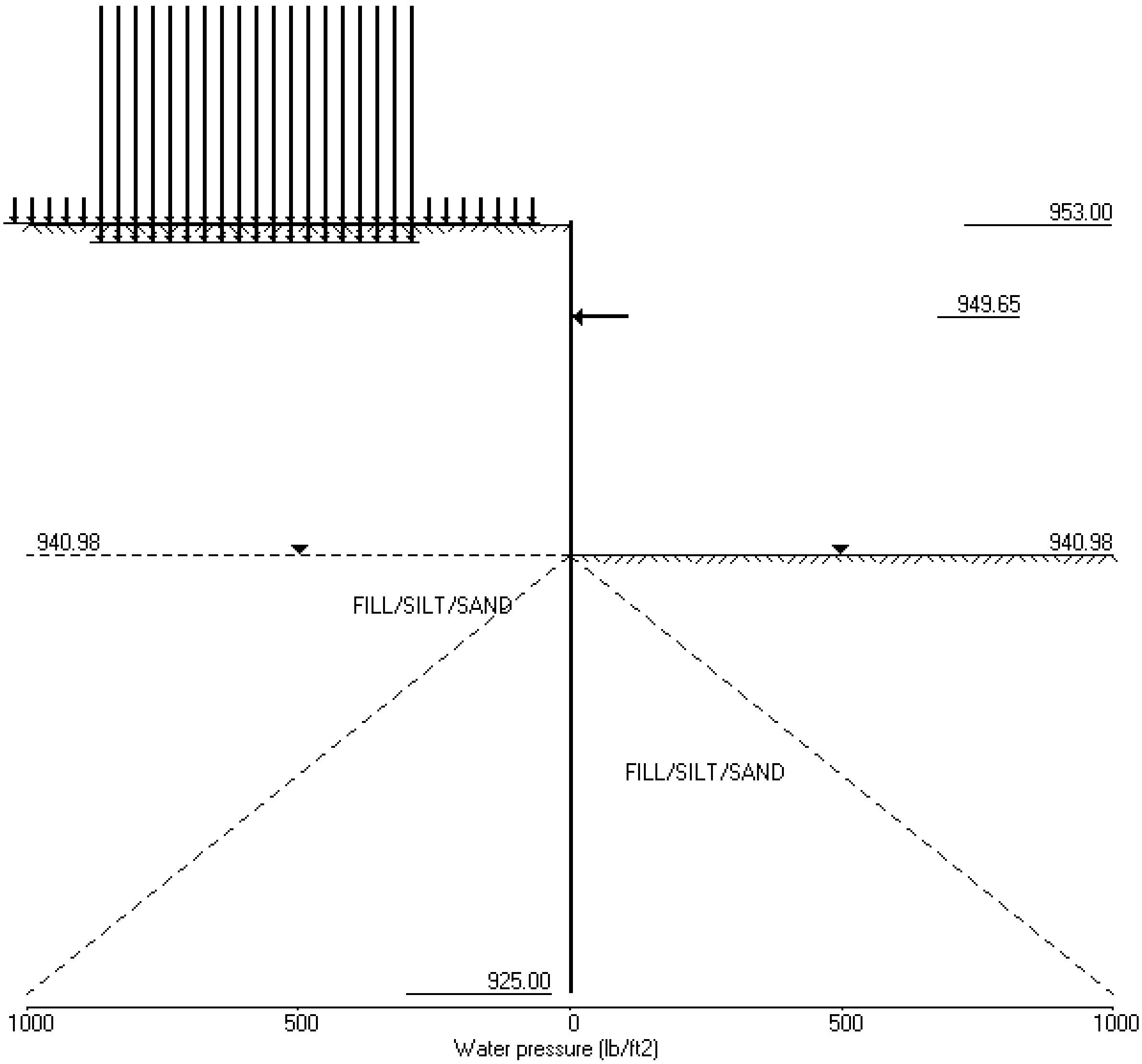
Units: lb,ft


Stage No.5 Excav. to elev. 940.98 on RIGHT side
Bending moment (lb.ft/ft run)
20000
0
-20000
952
944
Elev.
936
928
-4000
0
4000
Shear force (lb/ft run)
Displacement (ft)
-0.1000
0
0.1000
952
944
Right GL
Elev.
936
928


Stage No.5 Excav. to elev. 940.98 on RIGHT side
Active pressure (lb/ft2)
4000
0
-4000
952
A+P limits
(total stress)
944
Elev.
936
928
-4000
0
4000
Passive pressure (lb/ft2)
Nett pressure (lb/ft2)
1000
0
-1000
952
944
Right GL
Elev.
936
928

Units: lb,ft

Stage No.6 Apply water pressure profile no.1



Units: lb,ft

Stage No. 6 Apply water pressure profile no.1

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method

Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 925.00		Toe elev. for FoS = 2.000		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
6	953.00	940.98	949.65	2.073	n/a	925.52	15.46	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Node no.	Y coord	Nett pressure lb/ft2	Wall disp. ft	Wall rotation rad.	Shear force lb/ft	Bending moment lb.ft/ft	Prop forces lb/ft
1	953.00	0.00	0.058	4.35E-04	0.0	0.0	
2	952.25	106.15	0.058	4.35E-04	39.8	3.2	
3	950.95	205.89	0.057	4.33E-04	242.6	165.2	
4	949.65	161.90	0.057	4.26E-04	481.7	670.1	-4375.6
		161.90	0.057	4.26E-04	-3893.9	670.1	
5	948.33	239.74	0.056	4.59E-04	-3627.8	-4324.4	
6	947.00	420.04	0.055	5.79E-04	-3190.7	-8868.1	
7	945.50	608.51	0.054	8.05E-04	-2419.3	-12978.8	
8	944.00	691.94	0.053	1.10E-03	-1444.0	-15795.5	
9	942.49	778.32	0.051	1.44E-03	-334.0	-17079.6	
10	940.98	905.86	0.049	1.79E-03	937.6	-16595.5	
11	940.09	699.03	0.047	1.98E-03	1651.8	-15422.1	
12	939.20	439.88	0.045	2.16E-03	2158.6	-13704.2	
13	937.60	60.23	0.041	2.42E-03	2558.7	-9947.2	
14	936.00	-276.32	0.037	2.60E-03	2385.8	-5819.2	
15	934.40	-451.16	0.033	2.69E-03	1803.8	-2223.0	
16	932.80	-492.49	0.029	2.71E-03	1048.9	35.8	
17	931.20	-388.12	0.024	2.70E-03	344.4	1080.0	
18	929.60	-194.03	0.020	2.67E-03	-121.3	1152.3	
19	928.00	-15.01	0.016	2.65E-03	-288.5	703.0	
20	926.50	32.97	0.012	2.64E-03	-275.1	223.8	
21	925.00	333.77	0.008	2.64E-03	-0.0	0.0	

At elev. 949.65 Prop force = 4375.6 lb/ft run

(continued)

Stage No.6 Apply water pressure profile no.1

LEFT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	1524
2	952.25	0.00	106.76	33.62	427.04	106.15	106.15	9143
3	950.95	0.00	321.10	106.74	1284.39	205.89	205.89	24990
4	949.65	0.00	547.66	161.90	2190.66	161.90	161.90a	9443
5	948.33	0.00	804.95	239.74	3219.79	239.74	239.74a	13178
6	947.00	0.00	1075.38	420.04	4301.50	420.04	420.04a	16913
7	945.50	0.00	1376.41	590.53	5505.63	608.51	608.51	21141
8	944.00	0.00	1659.56	641.47	6638.24	691.94	691.94	25370
9	942.49	0.00	1922.94	689.88	7691.78	778.32	778.32	29626
10	940.98	0.00	2165.87	762.35	8663.48	905.86	905.86	33883
11	940.09	55.62	2245.04	768.83	8980.15	921.53	977.16	36391
12	939.20	111.25	2318.82	792.80	9275.30	884.89	996.14	38900
13	937.60	211.25	2440.03	905.33	9760.14	905.33	1116.58a	43410
14	936.00	311.25	2549.45	968.99	10197.81	968.99	1280.24a	47920
15	934.40	411.25	2649.96	932.29	10599.84	932.29	1343.54a	52431
16	932.80	511.25	2743.86	924.63	10975.44	924.63	1435.88a	56941
17	931.20	611.25	2832.95	1019.93	11331.78	1019.93	1631.18a	61451
18	929.60	711.25	2918.61	1162.18	11674.42	1162.18	1873.43a	65961
19	928.00	811.25	3001.89	1244.87	12007.57	1244.87	2056.12a	70471
20	926.50	905.00	3078.53	1159.53	12314.13	1159.53	2064.53a	74699
21	925.00	998.75	3154.29	1056.27	12617.15	1224.79	2223.54	78928

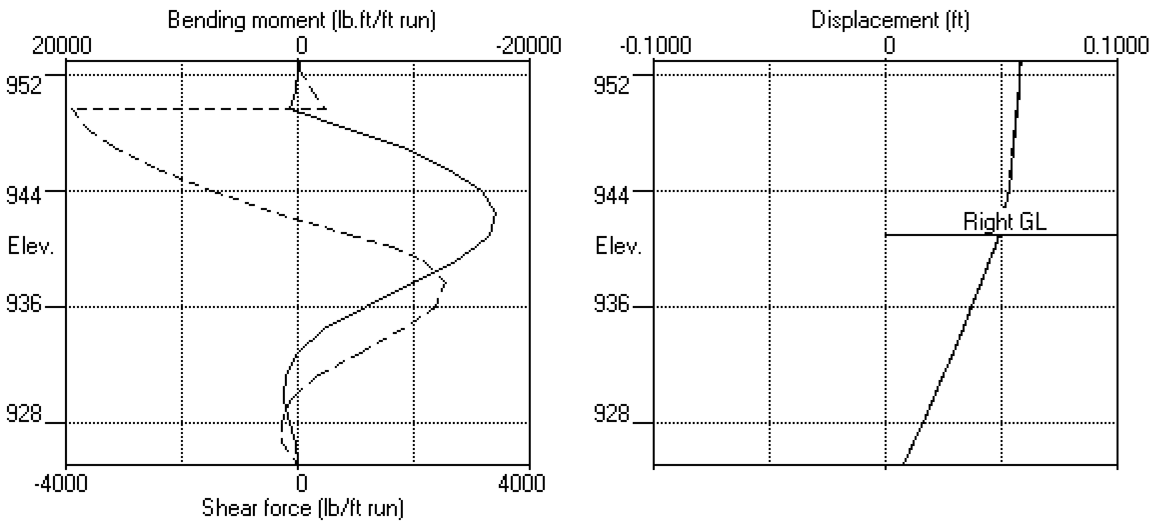
RIGHT side

Node no.	Y coord	Water press. lb/ft2	Vertic -al lb/ft2	Effective stresses Active limit lb/ft2	Passive limit lb/ft2	Earth pressure lb/ft2	Total earth pressure lb/ft2	Coeff. of subgrade reaction lb/ft3
1	953.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	952.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	950.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	949.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	948.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	947.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	945.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	944.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	942.49	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	940.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	462
11	940.09	55.62	55.63	14.78	222.50	222.50	278.13p	2773
12	939.20	111.25	111.25	31.45	445.01	445.01	556.26p	5545
13	937.60	211.25	211.27	60.53	845.10	845.10	1056.35p	10530
14	936.00	311.25	311.33	89.84	1245.31	1245.31	1556.56p	15515
15	934.40	411.25	411.43	119.25	1645.72	1383.45	1794.70	20499
16	932.80	511.25	511.60	148.61	2046.38	1417.12	1928.37	25484
17	931.20	611.25	611.84	177.77	2447.36	1408.05	2019.30	30468
18	929.60	711.25	712.18	207.02	2848.70	1356.20	2067.45	35453
19	928.00	811.25	812.62	236.29	3250.47	1259.88	2071.13	40437
20	926.50	905.00	906.89	265.75	3627.55	1126.56	2031.56	45110
21	925.00	998.75	1001.27	295.65	4005.10	891.02	1889.77	49784

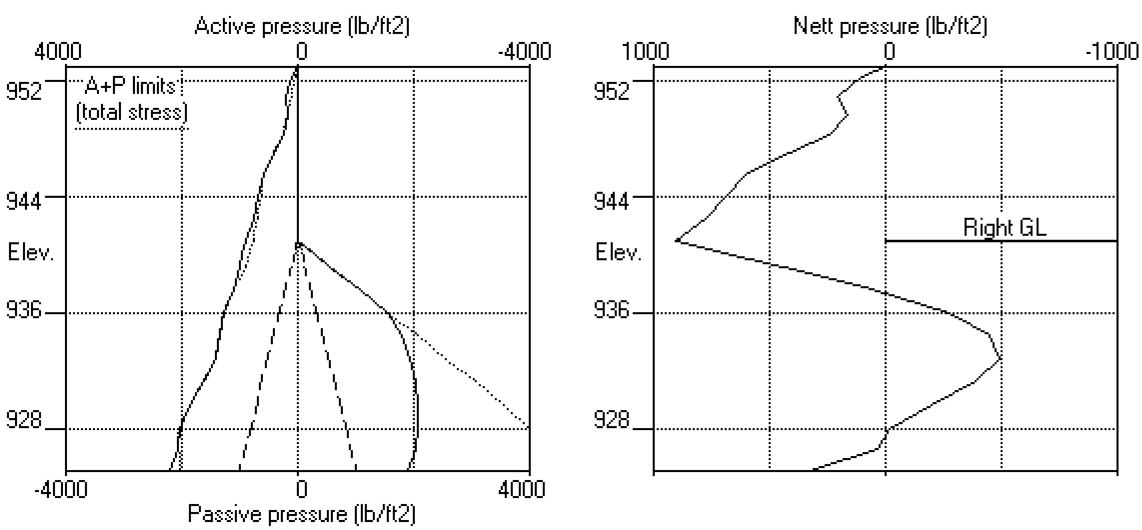
Note: 2064.53a Soil pressure at active limit
1556.56p Soil pressure at passive limit

Units: lb,ft

Stage No.6 Apply water pressure profile no.1



Stage No.6 Apply water pressure profile no.1



Units: lb,ft

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to CP2 method
Factor of safety on gross pressure (excluding water pressure)
Active limit pressures calculated by Wedge Stability

				FoS for toe elev. = 925.00		**Toe elev. for FoS = 2.000**		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	953.00	947.00	Cant.	4.017	927.18	935.59	11.41	L to R
2	953.00	947.00	Cant.	3.575	927.14	934.18	12.82	L to R
3	953.00	947.00	Cant.	2.122	926.55	926.36	20.64	L to R
4	953.00	947.00		No analysis at this stage				
5	953.00	940.98	949.65	2.331	n/a	927.05	13.93	L to R
6	953.00	940.98	949.65	2.073	n/a	925.52	15.46	L to R

Units: lb,ft

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00ft
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Active limit pressures calculated by Wedge Stability
Open Tension Crack analysis - No

Rigid boundaries: Left side 100.00 from wall
Right side 100.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum ft	Displacement minimum ft	Bending moment maximum lb.ft/ft	Bending moment minimum lb.ft/ft	Shear force maximum lb/ft	Shear force minimum lb/ft
1	953.00	0.068	0.000	0.0	0.0	0.0	0.0
2	952.25	0.066	0.000	3.2	0.0	39.8	0.0
3	950.95	0.061	0.000	165.2	0.0	242.6	0.0
4	949.65	0.057	0.000	670.1	0.0	481.7	-3893.9
5	948.33	0.056	0.000	843.1	-4324.4	544.5	-3627.8
6	947.00	0.055	0.000	1830.7	-8868.1	988.1	-3190.7
7	945.50	0.054	0.000	3831.3	-12978.8	1484.3	-2419.3
8	944.00	0.053	0.000	6310.5	-15795.5	1649.5	-1444.0
9	942.49	0.051	0.000	8782.0	-17079.6	1501.4	-334.0
10	940.98	0.049	0.000	10858.0	-16595.5	1187.6	0.0
11	940.09	0.047	0.000	11823.4	-15422.1	1727.6	0.0
12	939.20	0.045	0.000	12573.3	-13704.2	2158.6	0.0
13	937.60	0.041	0.000	13260.2	-9947.2	2558.7	-45.2
14	936.00	0.037	0.000	13047.0	-5819.2	2385.8	-411.6
15	934.40	0.033	0.000	12138.2	-2223.0	1803.8	-892.1
16	932.80	0.029	0.000	10303.1	0.0	1048.9	-1309.8
17	931.20	0.024	0.000	7898.8	0.0	344.4	-1587.5
18	929.60	0.020	0.000	5216.2	0.0	0.0	-1637.4
19	928.00	0.016	0.000	2678.9	0.0	0.0	-1394.8
20	926.50	0.012	0.000	901.7	0.0	0.0	-897.4
21	925.00	0.008	0.000	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum lb.ft/ft	elev.	Bending moment minimum lb.ft/ft	elev.	Shear force maximum lb/ft	elev.	Shear force minimum lb/ft	elev.
1	7270.5	937.60	0.0	953.00	902.1	944.00	-864.6	931.20
2	8758.9	937.60	0.0	953.00	1081.9	944.00	-1041.3	931.20
3	13260.2	937.60	-0.0	925.00	1649.5	944.00	-1637.4	929.60
4	No calculation at this stage							
5	2836.4	931.20	-12180.4	942.49	2254.2	937.60	-3142.0	949.65
6	1152.3	929.60	-17079.6	942.49	2558.7	937.60	-3893.9	949.65

Summary of results (continued)

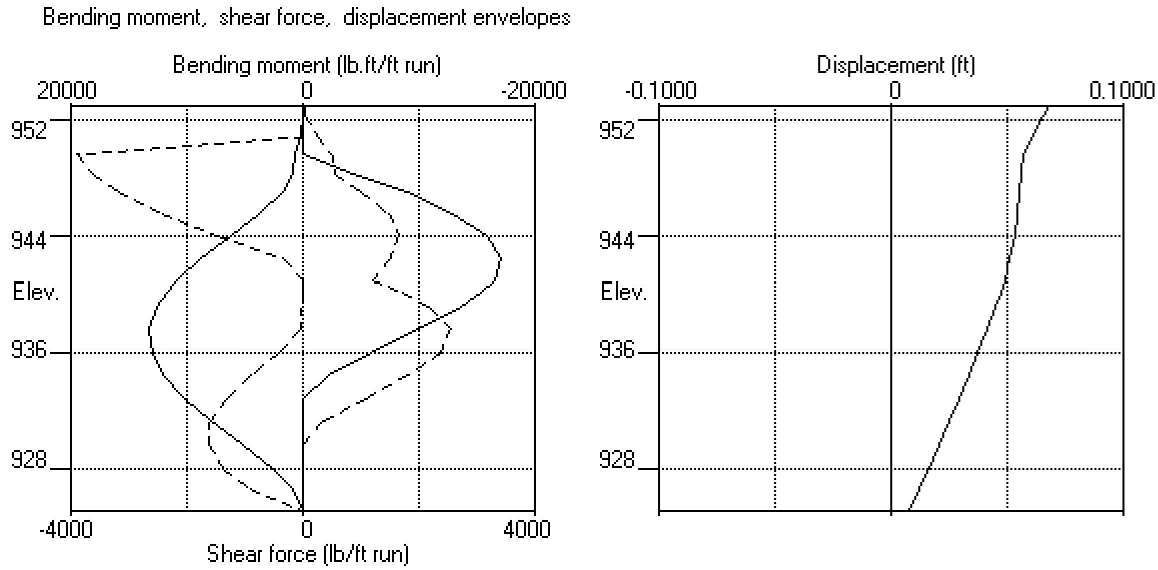
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum ft	elev.	minimum ft	elev.	Stage description
1	0.028	953.00	0.000	953.00	Excav. to elev. 947.00 on RIGHT side
2	0.034	953.00	0.000	953.00	Apply surcharge no.1 at elev. 953.00
3	0.068	953.00	0.000	953.00	Apply surcharge no.2 at elev. 952.25
4	No calculation at this stage				Install prop no.1 at elev. 949.65
5	0.061	953.00	0.000	953.00	Excav. to elev. 940.98 on RIGHT side
6	0.058	953.00	0.000	953.00	Apply water pressure profile no.1

Prop forces at each stage (horizontal components)

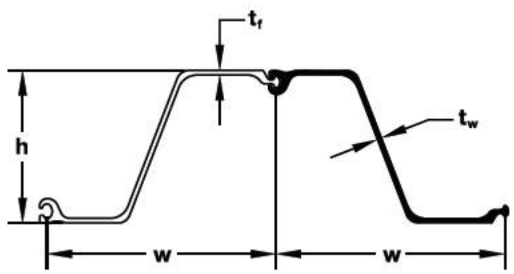
Stage no.	Strut no. 1 at elev. 949.65 lb/ft run	lb/prop
5	3575.49	3575.49
6	4375.64	4375.64

Units: lb,ft


Bending moment, shear force, displacement envelopes
Bending moment (lb.ft/ft run)
20000
0
-20000
952
944
Elev.
936
928
-4000
0
4000
Shear force (lb/ft run)
Displacement (ft)
-0.1000
0
0.1000
952
944
Elev.
936
928

PZ

PZ Hot Rolled Steel Sheet Pile



PZ

SECTION	Width (w)	Height (h)	THICKNESS		Cross Sectional Area	WEIGHT		SECTION MODULUS		Moment of Inertia	COATING AREA	
			Flange (t_f)	Web (t_w)		Pile	Wall	Elastic	Plastic		Both Sides	Wall Surface
	in mm	in mm	in mm	in mm	in²/ft cm²/m	lb/ft kg/m	lb/ft² kg/m²	in³/ft cm³/m	in³/ft cm³/m	in⁴/ft cm⁴/m	ft²/ft of single m²/m	ft²/ft² m²/m²
PZ 22	22.0 559	9.0 229	0.375 9.50	0.375 9.50	6.47 136.9	40.3 60.0	22.0 107.4	18.1 973	21.79 1171.4	84.38 11500	4.48 1.37	1.22 1.22
PZ 27	18.0 457	12.0 305	0.375 9.50	0.375 9.50	7.94 168.1	40.5 60.3	27.0 131.8	30.2 1620	36.49 1961.9	184.20 25200	4.48 1.37	1.49 1.49
PZ 35	22.6 575	14.9 378	0.600 15.21	0.500 12.67	10.29 217.8	66.0 98.2	35.0 170.9	48.5 2608	57.17 3073.5	361.22 49300	5.37 1.64	1.42 1.42
PZ 40	19.7 500	16.1 409	0.600 15.21	0.500 12.67	11.77 249.1	65.6 97.6	40.0 195.3	60.7 3263	71.92 3866.7	490.85 67000	5.37 1.64	1.64 1.64

I=361.22in^4/ft / (12^4) = 0.0174 ft^4/ft

PZ

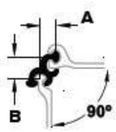
PZ Hot Rolled Steel Sheet Pile

Available Steel Grades

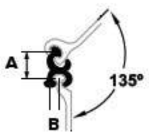
PZ		
ASTM	YIELD STRENGTH	
	ksi	MPa
A 328	39	270
A 572 Grade 50	50	345
A 572 Grade 60	60	415
A 588	50	345
A 690	50	345

Highlighted fields represent the most commonly used and readily available steel grades.

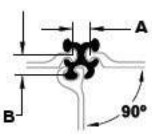
Corner Piles



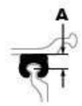
SKP90
Gr: A 572 Gr. 50
Wt: 8.97 lb/ft 13.3 kg/m
A: 1.24" 31.5 mm
B: 1.76" 37.1 mm



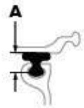
SKP45
Gr: A 572 Gr. 50
Wt: 9.08 lb/ft 13.5 kg/m
A: 2.05" 52.1 mm
B: 0.70" 17.8 mm



SKPT
Gr: A 572 Gr. 50
Wt: 11.30 lb/ft 16.8 kg/m
A: 1.23" 31.2 mm
B: 1.46" 37.1 mm

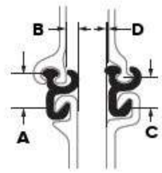


SKPF
Gr: A 572 Gr. 65
Wt: 6.13 lb/ft 9.1 kg/m
A: 0.96" 24.4 mm



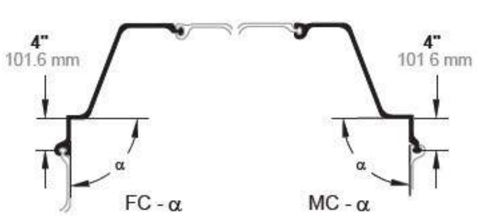
SKPM
Gr: A 572 Gr. 65
Wt: 6.13 lb/ft 9.1 kg/m
A: 1.26" 32.0 mm

Transitional Piles

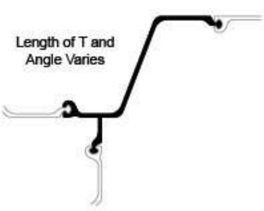


SKAP
Gr: A 572 Gr. 50/60
Wt: 8.95 lb/ft 13.3 kg/m
A: 1.97" 50.0 mm
B: 0.69" 17.5 mm
C: 1.61" 40.9 mm
D: 0.02" 0.5 mm

Fabricated Corner Piles



Female or Male Corner



T Pile

Delivery Conditions & Tolerances

	ASTM A 6	
Mass	± 2.5%	
Length	+ 5 inches	– 0 inches

Maximum Rolled Lengths*

PZ	105.0 feet	(32.0 m)

* Longer lengths may be possible upon request.

Interlock Combinations

	Client	HDR Engineering, Inc.			Page	
GEI Consultants	Project	MassDOT Berkshire Line Bridges			Pg. Rev.	
	By	J. Christensen	Chk.	N/A	App.	
	Date	07/06/2021	Date	N/A	Date	
Project No.	1703257	Document No.	N/A			
Subject	Bridge 79.90					

Boring Logs from Bridge 79.90

The soil properties used in the WALLAP analyses were based on the following borings.

BORING INFORMATION

BORING B401

PAGE 1 of 4

LOCATION: Bridge 79.90, North Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
TOTAL DEPTH (ft): 89.8
LOGGED BY: D. Litton
DATE START/END: 10/2/2018 - 10/3/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.
DRILLER NAME: Tim Van Ness
RIG TYPE: CME Hi-Rail Mounted Truck Rig

DRILLING INFORMATION

HAMMER TYPE: Automatic
AUGER I.D./O.D.: NA / NA
CASING I.D./O.D.: 4 inch / 4.5 inch
DRILL ROD O.D.: 2.675 inch
CORE BARREL TYPE: NA
CORE BARREL I.D./O.D. NA / NA
DRILLING METHOD: Driven casing and washed wi h rotary tooling.
WATER LEVEL DEPTHS (ft): Not measured

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I D /O D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
							SAND AND GRAVEL	(0-1'): BALLAST.
		S1	1 to 3	24/7	8-4-4-4		SAND AND GRAVEL	S1: SILTY SAND WITH GRAVEL (SM); ~60% fine to coarse sand, ~25% fine to coarse gravel, ~15% non-plastic fines; brown to black; wet. <FILL>
950		S2	3 to 5	24/2	4-8-11-9		SAND AND GRAVEL	S2: SANDY LEAN CLAY (CL); ~60% low plastic fines, ~30% fine to medium sand; gray with black; wet. <FILL>
	5	S3	5 to 7	24/13	7-6-5-8		SILT AND SAND	S3: SILT WITH SAND (ML); ~65% non-plastic fines, ~25% fine sand; gray; wet.
		S4	7 to 9	24/14	12-12-14-14		SILT AND SAND	S4: SILT WITH SAND (ML); Similar to S3.
945								
	10					~10 ft, mix bentonite clay. Rig chatter ~11 ft.		
940								
	15	S5	14 to 16	24/16	12-11-6-4		SILT AND SAND	S5: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic to low plastic fines; tan; wet.
935								
	20	S6	19 to 21	24/14	12-16-17-15		SILT AND SAND	S6: SILTY SAND (SM); Similar to S5.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, North Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/2/2018 - 10/3/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B401

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	24 to 26	24/15	6-6-7-10		SILT AND SAND	S7: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic to low plastic fines; light brown; moist.
925	30	S8	29 to 31	24/15	4-3-4-5			S8: SANDY SILT (ML); ~65% non-plastic fines; ~35% fine sand; gray; wet. Liquifies with v bration / shaking.
920	35	S9	34 to 36	24/21	3/12"-1-1			S9: SANDY SILT (ML); Similar to S8.
915	40	S10	39 to 41	24/18	2-1-3-3			S10: SILTY SAND (SM); ~70% fine to medium sand, ~30% non-plastic fines; gray; wet.
910	45	S11	44 to 46	24/18	1-2-1/12"			S11: SILTY SAND (SM); ~60% fine sand, ~40% non-plastic fines; gray; wet.
905	50	S12	49 to 51	24/18	3-2-3-3			S12: SILT WITH SAND (ML); ~60% non-plastic to low plastic fines, ~40% fine sand; tan and gray; wet.
900	55	S13	54 to 56	24/12	3-6-8-7			S13: SILTY SAND (SM); ~80% fine to medium sand, ~20% non-plastic fines; tan; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, North Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/2/2018 - 10/3/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B401
PAGE 3 of 4

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	60	S14	59 to 61	24/11	4-7-7-10		SILT AND SAND	S14: SILTY SAND (SM); ~65% fine sand, ~35% non-plastic fines; tan; wet.
890	65	S15	64 to 66	24/14	WOH-6-7-8		SILT AND SAND	S15: SILTY SAND (SM); Similar to S14, except gray with tan bands.
885	70	S16	69 to 71	24/9	8-10-10-14		SILT AND SAND	S16: SILTY SAND (SM); ~85% fine to medium sand, ~15% non-plastic fines; tan; wet.
880	75	S17	74 to 76	24/8	8-11-13-16		GLACIAL OUTWASH	S17: WIDELY GRADED SAND WITH SILT (SW-SM); ~90% fine to coarse sand, 10% non-plastic fines; tan; wet.
875	80	S18	79 to 81	24/13	7-10-11-10		GLACIAL OUTWASH	S18: WIDELY GRADED SAND WITH SILT (SW-SM); Similar to S17.
870	85	S19	84 to 86	24/8	35-42-30-44	Rig chatter ~84 ft.	GLACIAL TILL	S19: WIDELY GRADED GRAVEL WITH SAND AND SILT (GW-GM); ~60% fine to coarse gravel up to 1.5 inch, ~30% fine to coarse sand, ~10% non-plastic to low plastic fines; tan to white; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, North Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/2/2018 - 10/3/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B401
PAGE 4 of 4

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
						Bit grinding between 86 to 89 ft.		
865		S20	89 to 89.8	9/6	32-50/3"			S20: WIDELY GRADED GRAVEL WITH SAND AND SILT (GW-GM); ~60% fine to coarse gravel up to 1 inch, ~30% fine to coarse sand, ~10% non-plastic to low plastic fines; tan; wet. Till.
	90							Bottom of boring at depth 89.8 feet. Grout mix: 2 bags (94- b) portland cement, 1 bag bentonite. Borehole backfilled with tremie grout to existing grade.
860								
	95							
855								
	100							
850								
	105							
845								
	110							
840								
	115							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION

LOCATION: Bridge 79.90, South Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
TOTAL DEPTH (ft): 98.0
LOGGED BY: D. Litton

DATE START/END: 10/4/2018 - 10/8/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.
DRILLER NAME: Tim Van Ness
RIG TYPE: CME Hi-Rail Mounted Truck Rig

BORING B402

PAGE 1 of 4

DRILLING INFORMATION

HAMMER TYPE: Automatic
AUGER I.D./O.D.: NA / NA
CASING I.D./O.D.: 4 inch / 4.5 inch
DRILL ROD O.D.: 2.675 inch
CORE BARREL TYPE: NX
CORE BARREL I.D./O.D. 2 inch / 3 inch
DRILLING METHOD: Driven casing and washed wi h rotary tooling.
WATER LEVEL DEPTHS (ft): Not measured

ABBREVIATIONS:
Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer
S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger
Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I D /O D. = Inside Diameter/Outside Diameter
NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
							SAND AND GRAVEL	(0-6"): BALLAST.
		S1	0.5 to 2.5	24/4	5-6-5-3		SAND AND GRAVEL	S1: WIDELY GRADED SAND WITH GRAVEL (SW); ~50% fine to coarse sand, ~45% fine to coarse gravel, ~5% non-plastic fines; black; moist. <FILL>
950		S2	2.5 to 4.5	24/3	6-8-12-10	Wood in drill wash ~4 ft.	SAND AND GRAVEL	S2: WIDELY GRADED GRAVEL WITH SAND (GW); ~80% fine to coarse gravel, ~15% fine to coarse sand, ~5% non-plastic fines; brown to black; wet. <FILL>
	5					Drill through timber.	SAND AND GRAVEL	
						Drill wash color change ~6 ft.	SILT AND SAND	
		S3	7 to 9	24/11	4-4-6-7		SILT AND SAND	S3: SILT WITH SAND (ML); ~85% non-plastic fines, 15% fine sand; gray; wet.
945	10	S4	9 to 11	24/19	9-13-11-15	Mix mud. Continue open hole.	SILT AND SAND	S4: SILTY SAND (SM); ~70% fine sand, ~30% non-plastic fines; gray; wet.
940	15	S5	14 to 16	24/10	8-9-3-4		SILT AND SAND	S5: SILTY SAND (SM); ~65% fine to medium sand, ~30% non-plastic fines, ~5% fine gravel; brown; wet. Wood fibers.
935	20	S6	19 to 21	24/13	5-9-6-8		SILT AND SAND	S6: SILTY SAND (SM); Similar to S3.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, South Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/4/2018 - 10/8/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B402
PAGE 2 of 4

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	24 to 26	24/14	7-7-6-9		SILT AND SAND	S7: SILT WITH SAND (ML); ~85% non-plastic to low plastic fines, ~15% fine sand; gray; wet. ~7 inch timber in spoon. Wood grain parallel to spoon.
925	30	S8	29 to 31	24/18	9-12-7-10			S8: SILTY SAND (SM); ~60% fine to medium sand, ~40% non-plastic fines; tan to gray; wet. Wood f bers.
920	35	S9	34 to 36	24/15	2-2-3-2	Use paint screen to clean timber f bers from tub.		S9: SILT WITH SAND (ML); ~75% non-plastic to low plastic fines, ~25% fine sand; gray with tan seams; wet.
915	40	S10	39 to 41	24/10	3-4-3-3			S10: SANDY SILT (ML); ~60% non-plastic fines, ~40% fine sand; tan; wet.
910	45	S11	44 to 46	24/13	2-2-2-1			S11: SANDY SILT (ML); Similar to S10, except gray.
905	50	S12	49 to 51	24/14	2-2-3-2			S12: LEAN CLAY WITH SAND (CL); ~85% low plastic fines, ~15% fine sand; gray with tan bands.
900	55	S13	54 to 56	24/10	3-3-4-5			S13: SANDY SILT (ML); ~60% non-plastic fines, ~40% fine sand; tan; wet.

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, South Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/4/2018 - 10/8/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B402

PAGE 3 of 4

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
895	60	S14	59 to 61	24/12	3-6-6-10		SILT AND SAND	S14: SILT WITH SAND (ML); ~75% non-plastic fines, ~25% fine sand; gray; wet.
890	65	S15	64 to 66	24/17	4-4-6-10		GLACIAL OUTWASH	S15: SILTY SAND (SM); ~55% fine sand, ~45% non-plastic fines; tan; wet.
885	70	S16	69 to 71	24/8	6-10-11-12		GLACIAL OUTWASH	S16: SILTY SAND (SM); ~65% fine sand, ~35% non-plastic fines; tan; wet.
880	75	S17	74 to 76	24/10	6-32-45-23		GLACIAL OUTWASH	S17 (0-6"): SILTY SAND (SM); Similar to S15.
						Rig chatter from 76 to 79 ft.	GLACIAL TILL	S17 (6"-10"): WIDELY GRADED GRAVEL (GW); ~85% fine to coarse gravel up to 1-inch, ~10% fine to coarse sand, ~5% non-plastic fines; gray; wet.
						Poss ble boulder ~78 ft.		
875	80	S18	79 to 81	24/15	54-34-27-45		GLACIAL TILL	S18: WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM): ~50% fine to coarse sand, ~40% fine to coarse gravel, ~10% non-plastic fines; tan to gray; wet.
						Rig chatter from 81 to 84 ft.		
870	85	S19	84 to 85.8	22/16	45-86-80-100/4"		GLACIAL TILL	S19: SILTY GRAVEL WITH SAND (GM); ~60% fine to coarse gravel, ~20% fine to coarse sand, ~20% non-plastic fines; tan, gray, and white; wet. Rock seam from 8"-10".

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, South Abutment
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/4/2018 - 10/8/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B402
PAGE 4 of 4

Elev. (ft)	Depth (ft)	Sample No.	Sample Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
865	90	C1	88 to 93	60/49	71	Core times (min/ft): 4, 6, 4, 6, 4	DOLOMITIC MARBLE	C1: DOLOMITIC MARBLE; Hard, joint ~60 degrees at 8" - 10", near horizontal joints at 14", 36", 47", moderately fractured from 5" - 11" , lightly weathered joints. 0 to 5", 14" to 36", and 36" to 47" single piece, white.
860	95	C2	93 to 98	60/32	50	Core times (min/ft): 3, 3, 5, 4, 4	DOLOMITIC MARBLE	C2: DOLOMITIC MARBLE; Hard, joints between 10 and 45 degrees at 5", 12", 24", 28", and 30", severely fractured 0-5", lightly weathered joints, light gray to white.
855	100							Bottom of boring at depth 98 ft. Borehole backfilled with tremie grout to existing grade.
850	105							
845	110							
840	115							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

BORING INFORMATION

LOCATION: Bridge 79.90, Mid-span

GROUND SURFACE EL. (ft): 953.7

VERTICAL DATUM: NAVD 88

TOTAL DEPTH (ft): 32.0

LOGGED BY: D. Litton

DATE START/END: 10/9/2018 - 10/9/2018

DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

DRILLER NAME: Tim Van Ness

RIG TYPE: CME Hi-Rail Mounted Truck Rig

BORING

B403

PAGE 1 of 2

DRILLING INFORMATION

HAMMER TYPE: Automatic

AUGER I.D./O.D.: NA / NA

CASING I.D./O.D.: 4 inch / 4.5 inch

DRILL ROD O.D.: 2.675 inch

CORE BARREL TYPE: NA

CORE BARREL I.D./O.D. NA / NA

DRILLING METHOD: Spun and driven casing and washed with rotary tooling.

WATER LEVEL DEPTHS (ft): ⊻ 3.3 10/9/2018 8:58 am

ABBREVIATIONS:

Pen. = Penetration Length
Rec. = Recovery Length
RQD = Rock Quality Designation = Length of Sound Cores>4 in / Pen.,%
WOR = Weight of Rods
WOH = Weight of Hammer

S = Split Spoon Sample
C = Core Sample
U = Undisturbed Sample
SC = Sonic Core
DP = Direct Push Sample
HSA = Hollow-Stem Auger

Qp = Pocket Penetrometer Strength
Sv = Pocket Torvane Shear Strength
LL = Liquid Limit
PI = Plasticity Index
PID = Photoionization Detector
I D /O D. = Inside Diameter/Outside Diameter

NA, NM = Not Applicable, Not Measured
Blows per 6 in.: 140-lb hammer falling 30 inches to drive a 2-inch-O D. split spoon sampler.

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
950	5							
		S1	6 to 8	24/8	1-1-2-8		S & G	S1: WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); 56.6% fine to coarse angular gravel, 32.6% fine to coarse sand, 10.8% non-plastic fines (from grain size analysis); black; wet. 4-inch timber in spoon. <FILL>
945		S2	8 to 10	24/16	34-38-84-33		S & G	S2 (0-6"): SILTY GRAVEL WITH SAND (GM); ~60% fine to coarse gravel, ~25% non-plastic to low plastic fines, ~15% fine to coarse sand; black; wet.
							SILT AND SAND	S2(6"-16"): SILTY SAND WITH GRAVEL (SM) ~40% fine to coarse sand, ~30% non-plastic fines, ~30% fine to coarse gravel; gray; wet.
	10	S3	10 to 12	24/15	17-19-20-16		SILT AND SAND	S3: SILT (ML); 94.6% non-plastic fines, 5.4% fine sand (from grain size analysis); gray; wet.
		S4	12 to 14	24/11	16-17-18-26		SILT AND SAND	S4: SILT WITH SAND (ML): ~75% non-plastic to low plastic fines, ~20% fine to coarse sand, ~5% fine gravel; gray; wet.
940	15	S5	14 to 16	24/18	20-26-30-33		SILT AND SAND	S5: SANDY SILT (ML); 72.1% non-plastic fines, 27.9% fine sand (from grain size analysis); gray; wet.
935	20	S6	20 to 22	24/16	10-17-18-17		SILT AND SAND	S6: SILT (ML); 89.7% non-plastic fines, 10.3% fine sand (from grain size analysis); gray; wet.
930								

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018. S1-S3 were taken with a 3-inch split spoon. Debris and organics were resting on top of stream bed.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90

CITY/STATE: Lenox, Massachusetts

GEI PROJECT NUMBER: 1703257

GEI Consultants

LOCATION: Bridge 79.90, Mid-span
GROUND SURFACE EL. (ft): 953.7
VERTICAL DATUM: NAVD 88
DATE START/END: 10/9/2018 - 10/9/2018
DRILLING COMPANY: Aquifer Drilling and Tes ing, Inc.

BORING B403
PAGE 2 of 2

Elev. (ft)	Depth (ft)	Sample No.	Depth (ft)	Pen./ Rec. (in)	Blows per 6 in. or RQD	Drilling Remarks/ Field Test Data	Layer Name	Soil and Rock Description
	25	S7	25 to 27	24/12	3-3-5-10		S LT AND SAND	S7: SILT (ML); ~90% non-plastic to low plastic fines; ~10% fine sand; gray to tan; wet.
925								
	30	S8	30 to 32	24/20	4-4-5-5			S8: SILT WITH SAND (ML); ~80% non-plastic fines, ~20% fine sand; gray and tan; wet.
								Bottom of boring at depth 32 ft. Borehole backfilled with tremie grout to existing grade.
920								
	35							
915								
	40							
910								
	45							
905								
	50							
900								
	55							

NOTES: Depths referenced to top of rail. Top of rail elevation based on preliminary survey drawings from C&C Consul ing Engineers, LLC dated November 21, 2018. S1-S3 were taken with a 3-inch split spoon. Debris and organics were resting on top of stream bed.

PROJECT NAME: MassDOT Berkshire Line Bridges, Bridge MP 79.90
CITY/STATE: Lenox, Massachusetts
GEI PROJECT NUMBER: 1703257

GEI Consultants

APPENDIX B

Housatonic Railroad

ON TRACK SAFETY MANUAL

EFFECTIVE:

0001 Hours, Tuesday July 1, 2014
(Supersedes October 1, 2004)

FOR THE GOVERNMENT OF EMPLOYEES ONLY

TABLE OF CONTENTS
REGULATIONS GOVERNING ON-TRACK SAFETY

TABLE OF CONTENTS
REGULATIONS GOVERNING BRIDGE WORKER SAFETY

REGULATIONS GOVERNING ON-TRACK SAFETY

The regulations herein are effective July 1, 2001. They must be observed by all Housatonic employees and contractor employees working on or within 4 feet of the outside rail of any Housatonic Railroad track.

The intention of these regulations is to guard against employees being struck by trains or on-track equipment while performing their duties.

This book contains all rules and procedures that apply to on-track safety, including the responsibility of Roadway Workers and procedures for providing protection from trains and on-track equipment.

All Roadway Workers must be qualified on the Operating Rules and when required by their duties, must be qualified on the Physical Characteristics of the territory they are required to work. Roadway Workers will be responsible to maintain all qualifications required.

Any employee providing on-track protection and each Lone Worker, as defined herein, must have a copy of this manual in his/her possession at all times.

Responsibilities of Employees

ROADWAY WORKERS

RW-1. Compliance
Each roadway worker is responsible for complying with the regulations governing On-Track Safety.

RW-2. Fouling
No roadway worker will foul tracks except when necessary in the performance of duty, and only then, in accordance with these rules.

RW-3. Before Fouling
Before fouling a track, ascertain that on-track safety is being provided.

RW-4. Good Faith Challenge
If you are given a directive that would violate an on-track safety procedure, you may make a good faith challenge to that directive. Inform the employee in charge of on-track safety that the on-track safety protection to be applied does not comply with the regulations governing On-Track Safety.

Remain in the clear of tracks until the conflict is resolved, as shown in rule RW-28.

RW-5. Safe Passage of Trains
No work may be attempted that would interfere with the safe passage of trains.

RW-6. Personal Protective Equipment
Roadway workers must wear a high visibility vest, or other approved garment, hard hat and safety glasses, when on or about the track.

RW-7. Clearing for Trains
On receiving warning or knowing of the approach of a train, all employees must clear tracks at least 15 seconds before the train reaches the point of work, discontinue all activity, and remain clear until safe to resume work.

EMPLOYEE IN CHARGE

RW-8. Employee in Charge
Every Roadway Work Group whose duty requires fouling a track shall have one roadway worker designated to provide on-track safety for all members of the group.

When two or more Work Groups are assembled to work as a single group, one foreman must be designated to take charge of the work and be responsible for the protection of the employees. Each foreman involved will be advised which one of them is to be Employee in Charge. In an emergency or until one foreman has been designated, the foreman in whose territory the work is being performed will take charge, but if he is not present, the foremen will agree as to which one of them will be in charge. The Employee in Charge will advise each of the other foremen what his duties will be with respect to the safety of their employees.

The designated employee shall be qualified on the NORAC Operating Rules, Regulations Governing On-Track Safety, and the physical characteristics of the territory where the work will be performed.

RW-9. Responsibilities
The Employee in Charge of on-track protection is responsible for a safe operation and must exercise precaution to protect the employees in his/her charge. The Employee in Charge must.

a) Conduct job briefings with each employee that include the on-track safety protection that will be provided and the safety procedures that will be followed.

b) Get an acknowledgment from each roadway worker that the job briefing was understood.

c) If the on-track protection changes during the work period, inform each employee before the change becomes effective, except in an emergency. If the employee cannot be notified in advance because of an emergency, have the employee clear the track immediately, and stay clear until on-track protection is established.

d) Notify all employees before the Working Limits are released for the operation of trains. Do not release the Working Limits until all affected employees have either left the track or have been given on-track protection.

RW-10. Job Briefing

All Roadway Workers whose duties require the coordination between two or more workers must perform a job briefing prior to starting their job. The Roadway Worker must acknowledge that they have a clear understanding of the task, how it is to be accomplished and the on-track protection procedure to be used.

Job Briefings should be conducted face to face. When not practical or possible to do so, radio or telephone can be used. Discussion between employees must include, but is not limited to, the following:

1. The specific job to be performed for the day. Example: Installing ties at new interlocking under construction.

2. What type of protection the Employee in Charge intends to use. Example: Depending on the nature of the work, the affected track will be taken out of service, obstructed, or Foul Time will be requested.

3. Responsibilities of each employee. Example: Which foreman will be in charge of the Work Group.

4. Any known hazards or situations that could jeopardize personal safety. Example: The adjacent track is in service and trains will be passing work site at Normal Speed.

5. How equipment is to be operated, and which communication method will be used. Example: Who will give the crane operator hand signals.

6. Any requirements that will affect their job, such as orders to clear the track by a certain time.

7. All known unusual conditions or situations that may affect their job assignment.

8. If necessary to work under traffic, where the Predetermined Place of Safety(PPOS) location will be to clear the track. Employees must **not** clear the track by occupying another track unless that track is out of service.

Job Briefing should be updated regularly. When there is more than one foreman on the jobsite only one foreman can be in charge of the worksite. The foremen in charge must keep all other foreman up-to-date and must have a clear understanding as to how the job is to be conducted.

LONE WORKER

RW-11. Lone Worker

Each Lone Worker will communicate at the beginning of each duty period with a supervisor or another designated employee in order to receive a job briefing. The Lone Worker will advise such person of the Lone Worker's planned itinerary and the procedures that the Lone Worker intends to use for on-track safety.

When communication channels are disabled, the Lone Worker may begin the work and conduct the job briefing as soon as communications are restored.

RW-12. Job Briefing for Lone Worker

All Roadway Workers whose duties require them to work alone and who are not part of any other work group must contact their supervisor before the start of their work and conduct a job briefing. The Roadway Workers must acknowledge that they have a clear understanding of the task and the on-track protection procedure to be used.

Job Briefings should include how the worker intends to protect him/herself against moving track equipment or trains.

Discussion between Lone Worker and his/her supervisor must include, but is not limited to, the following:

1. All specific jobs to be performed for the day. Example: Inspecting track between two specific locations.

2. Responsibilities of the Lone Worker. Example: What portions of the job will require “Individual Train Detection” and when the track would need to be taken out of service.

3. Any known hazards or situations that could jeopardize personal safety. Example: The adjacent track is in service and trains will be passing the Lone Worker at Normal Speed.

4. How communication will be established. Example: Will the Lone Worker be monitoring the radio and on which frequency.

5. Any requirements that will affect the job, such as orders to clear the track by a certain time if the track is to be taken out of service.

6. All known unusual conditions or situations that may affect the job assignment.

7. If necessary to work under traffic, where will the PPOS location be to clear the track. Employees must **not** clear the track by occupying another track unless that track is out of service.

Job Briefing should be updated regularly. When it is not possible to contact the supervisor another employee must be designated to conduct an updated job briefing. If no other M of W employee is available to conduct a job briefing, the Dispatcher must be contacted and a job briefing will be conducted with the Dispatcher.

TYPE OF ON-TRACK PROTECTION TO BE USED

RW-13. Type of Track
The Employee in Charge of on-track protection will determine if the track to be protected is:

a) Controlled Track.
b) Non-controlled Track.
c) Interlocking Limits.

RW-14. Employees Protected
The Employee in Charge of on-track protection will determine if the employee(s) to be protected are a Roadway Worker Group or a Lone Worker.

RW-15. Protection Available
The Employee in Charge of on-track protection will determine what types of protection are available based upon the type of track and the employees that need protection.

One of the following means of protection must be selected:

a) Exclusive use of track
b) Foul time
c) Inaccessible track
d) Individual train detection

RW-16. Exclusive Use of Track
Exclusive use of track establishes Working Limits on Controlled Track by one of two methods:

a) The Dispatcher or Block Operator withholds or restricts authority to move into the Working Limits as established by Form D Line 4, or Line 5.,

RW-17. Foul Time
Foul Time establishes Working Limits on controlled track Through exclusive track occupancy by:

a) The Dispatcher or Block Operator giving an employee verbal permission to foul a specific segment of controlled track during a specific time period.

Foul Time remains in effect until the employee to whom the Foul Time was issued reports clear of the track.

NOTE: Foul Time cannot be used if the work involves on-track equipment, or if the work will make the track structure unsafe for Normal Speed.

RW-18. Inaccessible Track
Inaccessible track establishes Working Limits on Non-controlled Track by using switches, derails, and/or M of W Watchmen to prevent access to the Working Limits.

RW-19. Individual Train Detection
Individual Train Detection (ITD) may be used under strictly defined circumstances by trained and qualified Lone Workers to provide on-track protection on certain tracks outside Working Limits.

Note: Lone Workers have the right to use on-track protection other than ITD if they feel it is necessary to perform their work safely.

RW-20. Watchmen/Lookouts

(Does not apply to HRRC)

RW-21. Train Coordination

(Does not apply to HRRC)

ESTABLISHING THE ON-TRACK PROTECTION

RW-22 Exclusive Use of Track
The following rules give procedures for establishing exclusive use of track.

(NORAC Rule 132)

Protection When Fouling Working on a Track; Protection in Unforeseen Conditions.

Trains must be fully protected against any known condition that may interfere with their safe passage.

If work on or adjacent to a track will create a condition interfering with the safe passage of trains, that work must not be attempted without permission of the employee in charge of the track.

On tracks where ABS, DCS, or Interlocking rules are in effect, the Dispatcher (or Operator when authorized by the Dispatcher) must assure that protection against trains in both directions has been provided as follows:

1. If the work involves on-track equipment or will disturb the track structure so that it would be unsafe for Normal Speed, Form D line 4 or Form D line 5 must be issued.

2. If the work will not disturb the track structure, the Dispatcher may verbally authorize Foul Time in accordance with NORAC Rule 140.

Form D line 4, Form D line 5, and Foul Time may be issued only to employees who are qualified on the operating rules and the physical characteristics of the territory involved.

If an event occurs or conditions are found that may interfere with the safe passage of trains and no protection has been provided, employees must immediately attempt to stop trains by radio communication to trains and the Dispatcher. They must provide flag protection in both directions as prescribed by NORAC Rule 130, paragraph (b), “Flag Protection Against Trains on Adjacent Tracks”. Flag Protection must be maintained until the unsafe condition has been corrected, or until employees are assured by the Dispatcher or Operator that other protection has been provided.

(NORAC Rule 133)

Removing a Track from Service

Whenever Form D line 4 is issued to remove a track from service, the following procedures will apply:

a. Action Required Prior to Issuance

The Dispatcher must not issue the Form D Line 4 authority until:

1. The affected track is clear of other movements that are not part of the work group

AND

2. Controlled signals leading to the affected track are in Stop position,

AND

3. Blocking devices are applied to the controls of switches and signals leading to the affected track.

These signals must not be displayed for movement leading to the out-of-service track, except as provided for in NORAC Rule 134, paragraph (a), “Movement in the Direction of the Out-of –Service Track”.

b. Addressees

Form D must be issued to both:

1. The employee requesting use of track,

AND

2. The Operators controlling entrance to the track.

c. Establishing Out-of-Service Limits

Each end of the out-of-service limits must be defined by one of the following physical features:

1. A whole mile post.
2. A station or other physical characteristic location.
3. A track barricade or flagman at a designated location.

(NORAC Rule 133, cont'd.)

d. Operation Within Out-of-Service Limits

The employee named in Form D Line 4 is in charge of the out-of-service limits. ABS, CSS, DCS, and Interlocking rules do not apply within the out-of-service limits. All movements must operate at Restricted Speed. Interlocking switches within the out-of-service limits must not be operated without permission of the employee in charge.

EXCEPTION: In territory where non-signalled DCS rules apply in both directions, the employee in charge of the out-of-service limits may authorize trains to operate within the out-of-service limits at Normal Speed not exceeding 30 MPH, when the following conditions have been met:

1. The track to be used must be clear and safe for the speed to be authorized.
2. All affected switches must be secured in normal position.
3. All affected Roadway Workers must be notified.
4. Permission must be given in the following manner: *"Extra 453 may proceed North through my out-of-service limits at Normal Speed (not exceeding 30 MPH) from A to B"* This permission must be repeated and confirmed before it is acted upon.
5. No following movements may be permitted behind the train given this authority.

The train must not reverse direction without the permission of the employee in charge. If permission is received, the movement must be made at Restricted Speed.

e. Additional Equipment Entering or Leaving Out-of-Service Limits.

1. Additional equipment may enter the out-of-service limits after:

(a) The person in charge of the additional equipment has received permission from the employee in charge of the out-of-service limits. The employee in charge of the out-of-service limits must show or read his copy of the Form D Line 4 to the person in charge of the additional equipment unless the limits are published by Bulletin Order.

(b) If movement to the out-of-service limits will involve passing a Stop Signal, the Dispatcher or Operator may then authorize movement in accordance with Rule 241.

(NORAC Rule 133, cont'd.)

g. Returning the Track to Service

When the track is to be returned to service, the employee in charge of the out-of-service track must take two actions:

1. He must notify the Dispatcher or Operator of any restrictions necessary for the safe passage of trains.

AND

2. He must ascertain that all track cars and trains are clear of the track, and notify the Dispatcher or Operator that they are clear.

   EXCEPTION: With the Dispatcher's permission, the track may be returned to service while it is still occupied by equipment. Before the track is returned to service, the employee in charge of the track must ensure that the equipment remaining on the track receives proper authority to occupy the track after it is returned to service. If the track is governed by Rule 261, permission must include direction of movement.

(NORAC Rule 135)

Protection by Stop Signs When an In-Service Track is Obstructed for Maintenance

Whenever Form D line 5 is to be issued in accordance with item 1 of Rule 132, “Protection When Fouling or Working on a Track,” the following procedures will apply. The “Working Limits” refers to the area designated by Form D line 5 or Bulletin Order, which must be identified by a whole milepost, station, or other physical characteristic location.

a. Addressees

Form D Line 5 must be issued to both:

1. The employee requesting to obstruct the track,

AND

2. Trains approaching the obstructed track.

EXCEPTION: When the Working Limits is published by Bulletin Order, issuance of Form D to approaching trains is not required.

b. Required use of Signs

The approach to the Working Limits must be indicated by an Approach Sign. The Approach Sign indication will not apply when permission is received to proceed past the stop sign.

The Working Limits must be indicated by a Stop Sign and a Working Limits Resume Speed Sign. A Working Limits Speed Limit Sign may be substituted for the Stop Sign when the track is not obstructed.

c. Action Required Prior to Issuance

The Dispatcher must not issue Form D line 5 authority until:

The affected track is clear of movements that are not part of the work group.

AND

The Employee in Charge has advised that all signs associated with the working limits have been properly placed.

(NORAC Rule 135, cont'd.)

d. Movements within Working Limits

A train must not enter the Working Limits until permission has been received from the employee in charge, unless a Working Limits Speed Limit Signs is displayed. The Employee in Charge must not authorize a train to enter the Working Limits or display a Working Limits Speed Limit Sign until he has been assured that the track through the Working Limits is not obstructed, and all Roadway Workers have been notified. Trains must not exceed 30 MPH through the Working Limits, unless directed by the Employee in Charge to operate at a higher or lower speed.

EXCEPTION: Trains and track cars that will be performing maintenance within the Working Limits:

1. May be admitted by the Employee in Charge while the Working Limits is still obstructed.

2. Must operate at Restricted Speed (ABS, DCS and CSS rules do not apply to such movements).

3. Must not leave the Working Limits without proper authority.

e. Interlocking Switches within Restricted Area

Dispatchers or Operators controlling interlocking switches within the Working Limits must line such switches for movements within the Working Limits and must apply blocking devices to the controls of those switches. These blocking devices must not be removed without permission of the Employee in Charge of the Working Limits. This requirement does not relieve employees operating within the Working Limits from complying with interlocking signal indications.

Before displaying a signal for a train to divert into the Working Limits, the Dispatcher must confirm with the Engineer that the train has permission to enter the Working Limits.

f. Trains in the Working Limits when Bulletin Order Item Becomes Effective.

Any train that is in the Working Limits when Bulletin Order becomes effective may continue at Normal Speed through the Working Limits. The Dispatcher must not issue Form D Line 5 until the limits are clear of movements that are not part of the Work Group.

Table 1. Minimum stopping distances From Approach Signs to Stop Signs on level or ascending grades.

Normal Speed (MPH)	Maximum Stopping Distance (feet)	
	Passenger	**Freight**
80	6,200	-------
70	4,700	-------
60	3,450	14,500
50	2,700	11,100
40	2,000	8,700
30	1,400	5,900
20	900	3,800
10	500	1,900

Table 2. Minimum stopping distances from Approach Signs to Stop Signs on descending grades. The approach distance from Table 1 should be increased as follows:

Grades	Increase	Grades	Increase
0 -.09%	None	1.01 % -1.10%	50%
.10% -.30%	10%	1.11% - 1.30%	60%
.31% - .50%	20%	1.31% - 1.40%	70%
.51% - .80%	30%	1.41% - 1.60%	80%
.81% - 1.00%	40%	1.61% 0 1.70%	90%

RW-23. Foul Time

The following rule gives the procedures for establishing Foul Time. Also refer to NORAC Rule 132, Protection When Fouling or Working On a Track, Protection In Unforeseen Conditions.

(NORAC Rule 140)

Foul Time may be issued only by the Dispatcher, or Operator when authorized by the Dispatcher.

a. Action Required Prior to Issuance

Before issuing or authorizing Foul Time, the Dispatcher must determine that no trains have been authorized to occupy the track segment to be fouled. In signaled territory, the Dispatcher must ensure that Stop Signals have been displayed and blocking devices applied to controls of switches and signals leading to the affected track. When trains are to be held at a TBS where blocking devices cannot be applied, the Dispatcher must issue Form D line 13 instructing the Operator to hold trains clear of the affected track.

b. Permission to Foul

Permission to foul the track must include the following information:

1. Title and name of employee receiving foul time.

2. Track designation

3. Track limits (between/at)

4. Time limits

The receiving employee must repeat this permission and the Dispatcher or Operator must then confirm it before the Foul Time becomes effective.

c. Releasing Foul Time

Once protection has been provided, it must be maintained until the employee who was granted the Foul Time has released the foul time. The release must include the employee’s title and name, and the track designation and limits being released. This information must be repeated by the Dispatcher or Operator, and confirmed by the employee releasing the foul time before blocking devices are removed.

(NORAC Rule 141)

Inaccessible Track

Roadway Workers may establish working limits on a track not controlled by the Dispatcher or Operator, by making the track inaccessible at each possible point of entry through one of the following means:

1. A switch or derail aligned to prevent access to the Working Limits and secured with an effective securing device, and properly tagged. The effective securing device and tag may be removed only by direction of the employee in charge of the Working Limits.

2. A remotely controlled switch aligned to prevent access to the Working Limits and secured with a blocking device by the employee who controls the switch. Blocking device protection must not be considered in effect until is has been confirmed by the employee controlling the switch. Protection must be maintained until the employee who requested the protection has reported clear.

3. A disconnected rail.

4. A flagman assigned to hold trains and equipment clear of the Working Limits.

Movements within Working Limits may be made only with permission of the employee in charge.

RW-24 Individual Train Detection

The following rules give procedures for using Individual Train Detection (ITD). If you are a Lone Worker and cannot comply with all the provisions of Individual Train Detection, you must establish another form of on-track protection before you foul any track.

Individual Train Protection
(Watching For Trains Yourself)

If you are a Lone Worker who fouls a track while performing routine inspection or minor correction, you may watch for trains yourself only if all of the following eight conditions are met:

1. You are trained and qualified to use Individual Train Detection (ITD).

2. You are not within an Interlocking.

3. You are able to visually detect the approach of a train moving the maximum speed authorized for that track and

move to a previously determined place of safety at least 15 seconds before the train reaches you.

Note: The place of safety may not be another track unless Working Limits are established on that track.

4. There are not power-operated tools or roadway maintenance machines in use within your range of hearing.

5. Your ability to see and hear approaching trains and other on-track equipment is not impaired by background noise, lights, fog, precipitation, passing or standing trains, or any other physical conditions.

6. You may not occupy a position or engage in any activity that would interfere with your ability to maintain a vigilant lookout for, and detect the approach of, a train moving in either direction.

7. You must participate in a job briefing with your supervisor or other designated employee, such as the Dispatcher or Block Operator, at the beginning of your tour of duty. This briefing must include:

   a) Your Planned itinerary,

AND

   b) The on-track protection you plan to use.

EXCEPTION: If you are not able to communicate with the designated employee due to a communications failure, you may begin the work and conduct the job briefing as soon as communications are restored.

8. You have completed a Statement of On-Track Safety. Only one statement can be in effect at a time.

RW-25 Watchmen

(Does not apply to HRRC)

PERFORMING THE WORK AND CLEARING THE TRACK

The following rules must be followed while operating roadway maintenance machines and when clearing the tracks.

RW-26 Operating Self-propelled Equipment
Follow these precautions when operating self-propelled equipment:

1. The employee must be qualified or must be a trainee under the supervision of a qualified employee.

2. Keep the Operator's Manual available on the equipment to determine safe operating procedures.

3. Communicate with any employee(s) who are near the equipment regarding:

   a) Normal equipment operating procedures.

   b) Location of employees working around or observing the equipment.

   c) Operator's blind spots.

   d) Signals warning that the equipment will move.

4. Do not get closer than 15 feet to employees working on the track in front of or behind the equipment unless:

   a) The operation requires employees to be closer,

AND

   b) You have communicated with the affected employees.

5. Keep at least 30 feet from standing or working equipment to avoid collisions. Increase the distance between machines when:

   a) The equipment is working on territory where grades or curves limit the sight distance,

OR

   b) The rail is wet, icy, or slippery.

EXCEPTION: When the operation requires, the 30 foot distance between equipment may be reduced after arrangements have been made with all affected employees to ensure that no employees are between the equipment.

6. Consider the following factors when determining a working speed for the equipment:

   a) Location of employees required to be on the track in the area.

   b) Operator's visibility.

   c) Braking distance.

   d) Speed required to do the job.

   e) Physical characteristics of the track.

   f) Environmental conditions.

7. Do not foul the track with any part of the equipment unless:

   a) The adjacent track is a controlled track and exclusive use or Foul Time has been established on the track.
   b) The adjacent track is a non-controlled track and the track has been made inaccessible.

8. Test the brakes immediately after starting to travel.

9. When employees are getting on, getting off, or between self-propelled equipment, disengage the clutch or gears and set the brakes to hold.

10. Do not allow anyone to distract you or interfere with your duties. If this happens, stop all movement.

RW-27 Clearing Tracks
The following rules give procedures for clearing tracks.
(NORAC Rule 808)

Clearing a Track Specified on Form D Line 2

When a track car clears the track specified on Form D line 2, the Form D authorizing the use of the track is fulfilled, and a new Form D must be issued for any further movement. The Foreman or Track Car Driver must report clear to the Dispatcher or Operator.

Safety Precautions For Clearing All Tracks

Follow these safety precautions when clearing tracks:

1. When you are notified or become aware of the approach of a train, stop all work. Clear the tracks at least 15 seconds before the train reaches you.

2. Move to the location established by the Employee in Charge during the job briefing.

Note: You may not clear onto another track unless Working Limits have been established on that track.

3. Stop all equipment and vehicles on the right of way while the train is passing.

4. Do not leave tools, objects, material, or equipment where they could be struck by the passing train.

5. Face the direction from which the train is approaching. Watch for projecting, dragging, or falling objects.

6. Inspect all passing trains. If you detect a dangerous condition, use any available means to warn the crewmembers on the passing train to stop. If the train does not stop at once, notify the Dispatcher.

7. Stay clear until you are notified that it is safe to resume work.

Clearing Controlled Tracks

Follow this procedure to clear a controlled track, which is any Track shown in the Timetable as being under the control of a Dispatcher, Block Operator, or Yard Master.

1. Clear all tracks, keeping at least 30 feet away from passing trains and equipment, if possible. Do not clear onto another in service track.

2. If you are operating equipment and you are within the gauge of the track, stay on your machine. If you are not within the gauge of the track, dismount the equipment and clear the track.

Clearing Non-Controlled Industrial and Yard Tracks

Follow these procedures when working on and clearing non-controlled track (industrial, Yard, or any other track not controlled by the Dispatcher, Block Operator or Yard Master):

1. If a train is approaching on an adjacent track, stop work and stand in the center of the track where you are working.

2. If you are a Lone Worker using ITD you must be governed by the following:

   a) The place of safety cannot be on a track that is not shown on your Statement of On-track Safety, unless Working Limits are established on that track.
   b) A maximum of three adjacent tracks may be shown on one Statement of On-track Safety.
   c) You must always be prepared to clear all tracks if necessary.

CHALLENGE RESOLUTION

HRRC Roadway Workers have the absolute right to challenge, in good faith, any directive that would violate any Regulation Governing On-Track Safety. The Roadway Worker will remain clear of the track until a challenge is resolved.

RW-28. Resolving an On-track Safety Challenge

When a Roadway Worker has concerns about any directive that would violate the Regulations Governing On-track Safety the following procedures will apply:

1. The Roadway Worker will discuss the on-track safety procedures at the work location with the Employee in Charge. The worker and the Employee in Charge will try to clarify any misunderstanding and will resolve any differences of opinion about the on-track safety procedures.

2. If the worker and the Employee in Charge are unable to resolve the conflict, the employee may challenge the on-track safety procedures. To issue such a challenge, the worker must:

   a) Do so in good faith. The worker must have an honest concern that the procedures in place do not comply with these on-track safety regulations.

   b) Be able to explain his/her concern about the proposed on-track safety procedures being applied.

3. If the worker decides to challenge the on-track safety procedures, he/she must:

   a) Notify the Employee in Charge.

   b) Notify any other Roadway Workers of his/her concern.

   c) Remain clear of the track.

   d) The worker will explain the reason(s) for their concern on a “Roadway Worker Challenge Form”.

   e) The worker will give the “Roadway Worker Challenge Form” to the Employee in Charge.

4. The Employee in Charge will review the Challenge Form and determine whether the worker’s statement of on-track safety procedures at the work location is accurate and the On-track Safety procedures comply with the Regulations Governing On-track Safety.

5. If the Employee in Charge determines that the worker's concerns are valid, the Employee in Charge changes the procedures so that they comply with the regulations. If the worker considers the challenge resolved, the Employee in Charge forwards the challenge form to the Division Engineer's office and the workers return to work.

6. If the Employee in Charge determines that the worker's concerns are not valid the Employee in Charge notifies the worker and documents the determination on the Challenge Form. If the worker considers the challenge to be resolved, the Employee in Charge forwards the Challenge Form to the Division Engineer's office and the worker returns to work.

7. If the worker does not consider the challenge to be resolved, the Employee in Charge will contact his /her supervisor for a resolution.

8. The Supervisor reviews the Challenge Form and determines whether the proposed on-track safety procedures at the work location comply with the regulations. The Supervisor will contact the employees named on the form to make this determination.

9. If the Supervisor determines that the challenge was valid, the Supervisor will arrange for the procedures to comply with the regulations. Once the procedures are in compliance, the worker(s) returns to work. If the Supervisor determines that the challenge was not valid, the Supervisor explains to the worker why the challenge was not valid. The challenge is considered resolved and the worker(s) return to work.

10. A copy of the completed challenge form will be forwarded to the Division Engineer's (or designee) office. For the purpose of this section, the title "Division Engineer" may also include Engineers of Track, Structures, and Signal Construction. The original copy of the completed challenge form must be sent to the Director of Rules and Safety (or designee).

TYPES OF PROTECTION	CONTROLLED TRACK		NON-CONTROLLED TRACK		INTERLOCKING	
	GANG	LONE	GANG	LONE	GANG	LONE
EXCLUSIVE USE OF TRACK	X	X			X	X
FOUL TIME	X	X			X	X
INACCESSIBLE TRACK			X	X		
INDIVIDUAL TRAIN DETECTION		X		X		

Responsibilities of Employees

BRIDGE WORKER SAFETY

RW-40. Compliance
Each roadway worker is responsible for complying with the regulations governing Bridge Worker Safety.

RW-41. Conditions Requiring Use of Fall Arrest Systems
When bridge workers work twelve feet or more above the ground or water surface, they shall be provided and shall use a personal fall arrest system or safety net system.

RW-42. Conditions That Do Not Require Use of Fall Arrest Systems

(1) If the installation of the fall arrest system poses a greater risk than the work to be performed, OR

(2) If the inspection of railroad bridges are conducted in full compliance with the following conditions:

(i) The railroad has a written program in place that requires training in, adherence to, and use of safe procedures associated with climbing techniques and procedures to be used;

(ii) Bridge workers have been trained and qualified according to that program to perform bridge inspections, have been previously and voluntarily designated to perform inspections under the provision of that program, and have accepted the designation;

(iii) Bridge workers are familiar with the appropriate climbing techniques associated with all bridge structures they are responsible for inspecting;

(iv) Bridge workers are engaged solely in moving on or about the bridge or observing, measuring and recording the dimensions and condition of the bridge and its components;

(v) Bridge workers are provided all equipment necessary to meet the needs of safety, including any specialized alternative systems required.

(3) Where bridge workers are working on a railroad bridge equipped with walkways and railings of sufficient height, width, and strength to prevent a fall, so long as bridge workers do not work beyond the railings, over the side of the bridge, on ladders or other elevation devices, or where gaps or holes exist through which a body could fall.

(4) This section shall not apply where bridge workers are performing repairs or inspections of a minor nature that are completed by working exclusively between the outside rails, including but not limited to, routine welding, spiking, anchoring, spot surfacing, and joint bolt replacement

RW-43. Procedures Prior to Use of Fall Arrest Systems
Prior to use and after any component or system is changed, bridge workers shall be trained in the application limits of the

equipment, proper hook-up, anchoring and tie-off techniques, methods of use, and proper methods of equipment inspection and storage.

RW-44. Components of a Fall Arrest System

All components of a personal fall arrest system shall conform to the following standards:

(1) Lanyards and vertical lifelines that tie off one bridge worker shall have a minimum breaking strength of 5,000 pounds.

(2) Self-retracting lifelines and lanyards that automatically limit free fall distance to two feet or less shall have components capable of sustaining a minimum static tensile load of 3,000 pounds applied to the device with the lifeline or lanyard in the fully extended position.

(3) Self-retracting lifelines and lanyards that do not limit free fall distance to two feet or less, ripstitch, and tearing and deformed lanyards shall be capable of withstanding 5,000 pounds applied to the device with the lifeline or lanyard in the fully extended position.

(4) Horizontal lifelines shall be designed, installed, and used under the supervision of a competent person, as part of a complete personal fall arrest system that maintains a safety factor of at least two.

(5) Lifelines shall not be made of natural fiber rope.

(6) Body belts shall not be used as components of personal fall arrest systems.

(7) The personal fall arrest system shall limit the maximum arresting force on a bridge worker to 1,800 pounds when used with a body harness.

(8) The personal fall arrest system shall bring a bridge worker to a complete stop and limit maximum deceleration distance a bridge worker travels to 3.5 feet.

(9) The personal fall arrest system shall have sufficient strength to withstand twice the potential impact energy of a bridge worker free falling a distance of six feet, or the free fall distance permitted by the system, whichever is less.

(10) The personal fall arrest system shall be arranged so that a bridge worker cannot free fall more than six feet and cannot contact the ground or any lower horizontal surface of the bridge.

(11) Personal fall arrest systems shall be worn with the attachment point of the body harness located in the center of the wearer's back
near shoulder level, or above the wearer's head.

(12) When vertical lifelines are used, each bridge worker shall be provided with a separate lifeline.

(13) Devices used to connect to a horizontal lifeline that may become a vertical lifeline shall be capable of locking in either direction.

(14) Dee-rings and snap-hooks shall be capable of sustaining a minimum tensile load of 3,600 pounds without cracking, breaking, or taking permanent deformation.

(15) Dee-rings and snap-hooks shall be capable of sustaining a minimum tensile load of 5,000 pounds.

(16) Snap-hooks shall not be connected to each other.

(17) Snap-hooks shall be dimensionally compatible with the member to which they are connected to prevent unintentional disengagement, or shall be a locking snap-hook designed to prevent unintentional disengagement.

(18) Unless of a locking type, snap-hooks shall not be engaged:

(i) Directly, next to a webbing, rope, or wire rope;
(ii) To each other;
(iii) To a dee-ring to which another snap-hook or other connector is attached;
(iv) To a horizontal lifeline; or
(v) To any object that is incompatibly shaped or dimensioned in relation to the snap-hook so that unintentional disengagement could occur.

RW-45. Components of a Safety Net System

Use of safety net systems shall conform to the following standards and practices:

(1) Safety nets shall be installed as close as practicable under the walking/working surface on which bridge workers are working, but shall not be installed more than 30 feet below such surface.

(2) If the distance from the working surface to the net exceeds 30 feet, bridge workers shall be protected by personal fall arrest systems.

(3) The safety net shall be installed such that any fall from the working surface to the net is unobstructed.

(4) Except as provided in this section, safety nets and net installations shall be drop-tested at the jobsite after initial installation and before being used as a fall protection system, whenever relocated, after major repair, and at six-month intervals if left in one place. The drop-test shall consist of a 400-pound bag of sand 30 inches, plus or minus two inches, in diameter dropped into the net from the highest (but not less than 3\1/2\ feet) working surface on which bridge workers are to be protected.

(i) When the railroad or railroad contractor demonstrates that a drop-test is not feasible and, as a result, the test is not performed, the railroad or railroad contractor, or designated competent person, shall certify that the net and its installation are in compliance with the provisions of this section by preparing a certification record prior to use of the net.

(ii) The certification shall include an identification of the net, the date it was determined that the net was in compliance with this section, and the signature of the person making this determination. Such person's signature shall certify that the net and its installation are in compliance with this section. The most recent certification for each net installation shall be available at the jobsite where the subject net is located.

(5) Safety nets and their installations shall be capable of

absorbing an impact force equal to that produced by the drop test specified in this section.

(6) The safety net shall be installed such that there is no contact with surfaces or structures below the net when subjected to an impact force equal to the drop test specified in this section.

(7) Safety nets shall extend outward from the outermost projection of the work surface as follows:

(i) When the vertical distance from the working level to the horizontal plane of the net is 5 feet or less, the minimum required horizontal distance of the outer edge of the net beyond the edge of the working surface is 8 feet.

(ii) When the vertical distance from the working level to the horizontal plane of the net is 5 feet, but less than 10 feet, the minimum required horizontal distance of the outer edge of the net beyond the edge of the working surface is 10 feet.

(iii) When the vertical distance from the working level to the horizontal plane of the net is more than 10 feet, the minimum required horizontal distance of the outer edge of the net beyond the edge of the working surface is 13 feet.

RW-46. Inspection of Safety Nets

Safety nets shall be inspected after any occurrence that could affect the integrity of the safety net system.

RW47. Working Over or Adjacent to Water

Bridge workers working over or adjacent to water with a depth of four feet or more, or where the danger of drowning exists, shall be provided and shall use life vests, or buoyant work vests with life preservers within ready access. This Rule does not apply to bridge workers using personal fall arrest systems or safety nets that comply with rule RW-44.

RW48. Use of River Craft

Where life vests are required, at least one lifesaving skiff, inflatable boat, or equivalent device shall be immediately available. If it is determined by a competent person that environmental conditions, including weather, water speed, and terrain, merit additional protection, the skiff or boat shall be manned.

RW49. Use of Scaffolding

Each scaffold and scaffold component, including footings and anchorage, shall be capable of supporting, without failure, its own weight and at least four times the maximum intended load applied or transmitted to that scaffold or scaffold component.

DEFINITIONS

Adjacent Tracks – Two or more track centers spaced less than 25 feet apart.

Anchorage – A secure point of attachment for lifelines, lanyards or deceleration devices that is independent of the means of supporting or suspending the employee.

Body Belt – A strap that can be secured around the waist or body and attached to a lanyard, lifeline, or deceleration device.

Blocking Device – A lever, plug, ring, or other method of control that restricts the operation of a switch or signal.

Control Operator – The railroad employee in charge of a remotely controlled switch or derail, an interlocking, a controlled point, or a segment of Controlled Track.

Controlled Track – Track upon which all movements must be authorized by a Train Dispatcher or Control Operator.

Deceleration Device – Any mechanism, including, but not limited to, rope grabs, ripstich lanyards, specially woven lanyards, and automatic self-retracting lifelines/lanyards that serve to dissipate a substantial amount of energy during a fall arrest, or otherwise limit the energy on a person during fall arrest.

Derail – A track safety device designed to guide a car off the rails at a selected spot as a means of protection against collisions or other accidents.

Effective Securing Device – A device used to prevent the operation of a manually operated switch or derail that is:

Vandal resistant,
Tamper resistant, and
Designed to be applied, secured, uniquely tagged, and removed only by the class, craft, or group of employees for whom protection is being provided.

Exclusive Track Occupancy - A method of establishing Working Limits on Controlled Track in which movement authority is withheld or restricted by the Train Dispatcher or Control Operator or where one or more approaches to the Working Limits are protected by flagmen.

Flagman – An employee designated to direct or restrict the movement of trains at a point on track to provide on-track protection for Roadway Workers, while engaged solely in performing that function.

Form D – See Movement Permit Form D.

Foul Time – A method of establishing Working Limits through exclusive use of the track in which notification is given and recorded by the Train Dispatcher or Control Operator to an employee that no trains will operate within a specific segment of Controlled Track during a specific time period, and the required blocking devices have been placed on the control machine to protect the track fouled. Foul Time shall remain in effect until the employee to whom the Foul Time was issued has reported clear of the track.

Fouling a Track – The location of an individual or equipment in such proximity to a track that the individual or equipment could be struck by a moving train or on-track equipment, or, in any case, within 4 feet of the field side of the running rail.

Inaccessible Track – A method of establishing Working Limits on Non-controlled Track by preventing access to the Working Limits.

Individual Train Detection (ITD) – A procedure that may be used under strictly defined circumstances by trained and qualified Lone Workers to provide on-track protection on certain tracks outside Working Limits.

Interlocking Limits – The tracks between the opposing home signals of an interlocking.

Lanyard – A flexible line of rope, wire rope, or strap that is used to secure a body harness to a deceleration device, lifeline, or anchorage.

Lone Worker – An individual employee who is not being afforded on-track protection by another employee, is not a member of a Roadway Work Group, and is not engaged in a common task with another Roadway Worker.

Movement Permit Form D – A form containing written authorization(s), restriction(s), or instruction(s), issued by the Dispatcher to specified individuals.

Non-Controlled Track – Track upon which trains are permitted by rules or special instructions to move without receiving authorization from a Train Dispatcher or Control Operator.

On-Track Roadway Maintenance Machine – A self propelled, rail mounted, non-highway, maintenance machine whose light weight in excess of 7,500 pounds, and whose purpose is not for the inspection of railroad track.

On-Track Roadway Maintenance Machine, new – A machine ordered after 12/26/03 and completed after 9/27/04.

On-Track Safety – The state of freedom from the danger of being struck by a moving railroad train or other equipment, provided by operating and safety rules that govern track occupancy by personnel, trains, and on-track equipment.

Personal Fall Arrest System – A system used to arrest a fall of a person from a working level.

Personal Place of Safety – A predetermined location where a Roadway Worker or group will occupy when it is necessary to clear a work location.

Pilot – An employee assigned to a train or track car when the Engineer, Conductor, or Track Car Driver is not qualified on the physical characteristics or the operating rules of the territory to be traversed.

Qualified Employee – An employee who has successfully completed all required training for, has demonstrated proficiency in, and has been authorized to perform the duties of, a particular position or function.

Railroad Bridge Worker – An employee of, or employee of a contractor of, a railroad responsible for the construction, inspection, or maintenance of a bridge whose assigned duties, if performed on the bridge, include inspection, testing, maintenance, repair, construction, or reconstruction of the track, bridge structural members, operating mechanisms and water traffic control systems, or signal, communication, or train control systems integral to that bridge.

Restricted Speed – A designation that requires the Operator to be prepared to stop within one-half the range of vision short of other trains or railroad equipment occupying or fouling the track, obstructions, switches not properly lined for movement, derails set in the derailing position, or any signal requiring a stop. Operator must be on the lookout for broken rail and misaligned track. Speed must not exceed 20 MPH outside interlocking limits, or 15 MPH within interlocking limits. This speed applies to the entire movement unless otherwise specified in the rule or instruction that requires Restricted Speed.

Roadway Maintenance Machine – Powered equipment, other than by hand, which is being used on or near the track for maintenance, repair, construction, or inspection of track, bridges, roadway, or signal, communication, or electric traction systems. These machines may have road or rail wheels or may be stationary.

Roadway Maintenance Work Train - A train which is being operated within Working Limits in conjunction with roadway maintenance, construction, or repairs, under the direction of a designated employee in charge.

Roadway Work Group – Two or more employees working together on a common task.

Roadway Worker – An employee of HRRC, or employee of a contractor of HRRC, whose duties include inspection, construction, maintenance, or repair of track, bridges, roadway, signal and communication systems, electric traction systems, roadway facilities, or roadway maintenance machinery on or near track with the potential of fouling a track, and an employee of HRRC or of a contractor of HRRC who is responsible for on-track protection.

Three-Step Protection – A procedure used by an engineer to protect employees before they foul equipment. Three-step protection has three components:

- Apply the brake.
- Center the reverser.
- Put the generator field in the OFF or OPEN position.

Track Barricade – A designated sign or obstruction fastened to a track that prevents access to the track.

Track Centers – The distance from the centerline of one track to the centerline of an adjacent track.

Warning Tag – Tag used to indicate that equipment is out of service and should not be operated.

Watchman (Train Approach Warning) – A method of establishing on-track protection by warning employees of the approach of trains in ample time for them to move to or remain at a place of safety in accordance with the Watchman Rules.

Working Limits – A segment of track within definite limits, established by NORAC rules, upon which trains and engines may move only as authorized by the Employee in Charge having control of the track within the Working Limits. Working Limits may be established through Exclusive Use of Track, Foul Time, or Inaccessible Track.

STATEMENT OF ON-TRACK SAFETY

Lone Workers who use individual train detection to establish on-track safety must complete this "Statement of On-track Safety" for each assignment. The statement shall be available for inspection by a railroad official or Federal Railroad Administration representative whenever the Lone Worker is using individual train detection. (49 CFR 214.335(f)).

Railroad Name:	**Housatonic Railroad**		
Lone Worker Name:			
Date:		Time:	
Job Location:			
Indicate track Limits the Lone Worker will be working:			
Date and time the Lone Worker will be using individual train detection at this location:			
Date:			
Start Time:			
End Time:			
Maximum authorized speed for trains at this location: MPH			
Sight distance at this location along the tracks where trains will be visible:			
Feet		Yards	
Lone Worker Signature:			

GOOD FAITH CHALLENGE FORM

The employee making challenge shall complete this form, sign and date it, and give it to his Supervisor who shall document this determination, sign and forward form to his immediate Supervisor.

Name:	**Housatonic Railroad**		
Job Position:			
Job Location:			
Supervisors Name		Title:	
Date and Time of Occurrence:			
Work Location:			
Nearest City/Town:			
On-Track Safety Procedure applied (or lacking) at working Location:			
Railroad Safety or Operating Rule not being complied with:			
Reason for this Challenge:			
Other Employees with information regarding this situation:			
Signature:		Date	
Determination by Supervisor:			
Supervisor Signature:		Date	

APPENDIX C

HOUSATONIC RAILROAD

Berkshire Line – CP-150, BL-86.60 to BL-80

South

Speed	DOT#	BL-Mileage	Location	Grade
YARD LIMITS		**86.60**	**CP-150** CSXT Berkshire Subdivision	
			Bridge, West Street	
		86	**Milepost**	
		85.88	Bridge (water)	
	526175J	85.52	Bridge, Route 20, W. Housatonic St.	
		85.32	Bridge, (water)	+0.6
		85.05	Switch, Long Siding	
		85	**Milepost, Pittsfield**	
YARD LIMITS	526176R	85.00	Bridge, Route 20, South Street	-0.7
		84.75	**PITT** – Yard Limits	
		84.15	Underground Gas Pipe (800) 292-5019	
		84	**Milepost**	
		83.89	Underground Gas Pipe (800) 231-2800	
	526177X	83.76	Bridge, Holmes Road	
	None	83.14	Bridge, Sewer Plant	
	932739J	83.07	Pittsfield Sewer Bed	
		83	**Milepost**	
	932738C	82.50	Overmeade Farm	
	526178E	82.08	New Lenox Road	
		82	**Milepost**	
		81	**Milepost**	
		80.72	Bridge (water)	+0.2
		80.57	Underground Cable (“911”)	
		80	**Milepost**	

Yard Limits –Restricted Speed Not Exceeding **10 MPH**

25 MPH

HRRC crews must contact CSXT “NB” Dispatcher prior to entering CSXT property at CP-150.

Telephone:(518) 767-6112

Long Siding
750 Feet

5 mph

EMERGENCY RESPONSE

Pittsfield Police Dept. (413) 448-9701

Lenox Police Dept. (413) 637-2346

Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-80 to BL-77

South

Speed	DOT#	BL-Mileage	Location
25 MPH		**80**	**Milepost**
		79.81	Bridge (water)
		79.41	North Switch, Lenox Team Track
		79.36	North Switch, Lenox Siding
		79.32	Switch, Lenox Valley Transfer
		79.22	Switch, Berkshire Scenic RR
		79.04	South Switch, Lenox Team Track
		79	**Milepost,** Lenox
	526179L	78.92	Housatonic Street
		78.87	South Switch, Lenox Siding
	526180F	78.47	Valley Mill
	526181M	78.31	Woods
		78	**Milepost**
	526182U	77.81	Private, Lenox Oil
		77.71	Bridge, Housatonic River
	526183B	77.61	Bridge, Mill Street
		77.28	Bridge
		77.04	Bridge (water)
		77	**Milepost**

Team Trk. 800 Feet

Lenox Siding 2111 Feet

STOP

Grade: +0.3

EMERGENCY RESPONSE

Lenox Police Dept. (413) 637-2346

Lee – (413) 243-5530

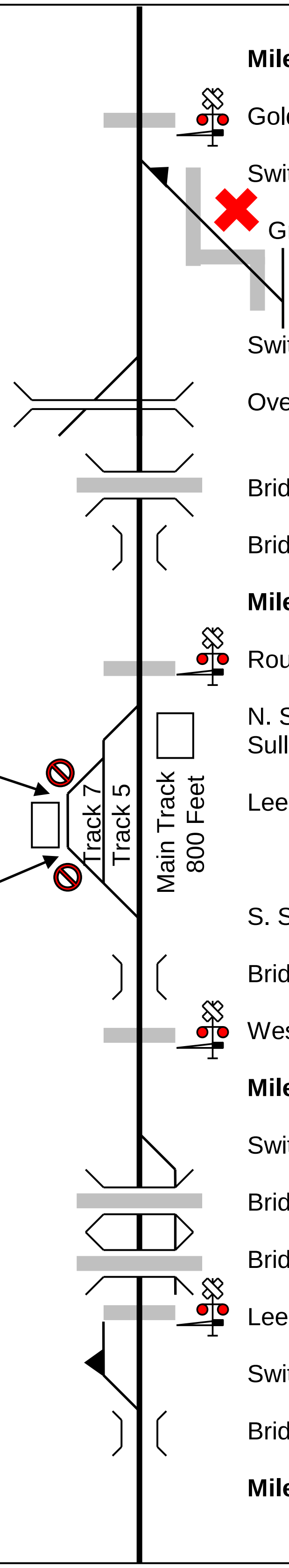
Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-77 to BL-74

South

Speed	DOT#	BL-Mileage	Location	Grade
25 MPH		**77**	**Milepost**	+0.2
	526184H	76.87	Golden Hill Road	
		76.77	Switch, Greylock Mill Road	
	526185P	76.67	Greylock Street (Side track) Must flag protect.	
		76.47	Switch, Columbia	
		76.44	Overhead Pipes	
	526186W	76.36	Bridge, Water Treatment	
		76.23	Bridge	
		76	**Milepost**	
	526188K	75.78	Route 20, Center Street	
		75.77	N. Switch, Lee Siding, Tracks 5 &7	
		75.74	Sullivan Station	
	Close Clearance, Track 7	75.60	Lee Yard	
	Close Clearance, Track 7	75.50	S. Switch, Lee Siding, Tracks 5 & 7	
		75.49	Bridge, Housatonic River	
	526189S	75.31	West Park Street	
		75	**Milepost**	
		74.92	Switch, Old Castle	
		74.84	Bridge, Mass Turnpike, West	
	526190L			
		74.83	Bridge, Mass Turnpike, East	
	526191T	74.67	Lee Lime	
		74.53	Switch, Pitt Track	
		74.17	Bridge	
		74	**Milepost**	



EMERGENCY RESPONSE

Lee Police Dept. (413) 243-5530

Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-74 to BL-68

South

Speed	DOT#	BL-Mileage	Location
25 MPH		**74**	**Milepost**
	526192A	73.88	Bridge, Pleasant Street, Rte. 102
	932737V	73.50	Country Curtain
		73	**Milepost**
		72.93	Switch, Onyx
	932736N	72.80	Mead Paper Dump
		72.45 Bridge 72.30	Bridge, Housatonic River
	526193G	72.21	Meadow Street
	526194N	72.12	Pine Street
		72	**Milepost**
	526195V	71.51	Willow Street
		71.40	Switch, Willow Mill
		71	**Milepost**
		70	**Milepost**
		69.84	North Switch, Stockbridge Siding
		69.72	Stockbridge
	526196C	69.66	Bridge, Route 7
		69.61	South Switch, Stockbridge Siding
		69.44 Bridge 69.56	Bridge
	526197J	69.05	Cherry Street
		69	**Milepost**
	526206F	68.61	Bridge, Glendale Middle Road
	526205Y	68.50	Glendale Middle Road
		68	**Milepost**

Stockbridge Siding
700 Feet

Grade

+0.1

+0.3

-0.5

+0.6

EMERGENCY RESPONSE

Lee Police Dept. (413) 243-5530

Stockbridge Police Dept. (413) 298-4179

Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-68 to BL-62

South

Speed	DOT#	BL-Mileage	Location	Grade
25 MPH		**68**	**Milepost**	
		67.5	Speed Change	
10 MPH		67.1	Speed Change	
		67	**Milepost**	
		66.89	Bridge, Housatonic River	
		Bridge 66.76		
	526204S	66.28	Furnace District Road	
		66	**Milepost**	
	932735G	65.51	Housatonic Station Road	
		65.45	Housatonic	
	526203K	65.38	Bridge, Private	
		Bridge 61.15		
	526202D	65.31	Bridge, Pleasant Street, Route 183	
		Bridge 61.09		
		65	**Milepost**	
		64.87	North Switch, Rising Siding	
25 MPH	526201W	64.48	Rising Crossing	
		64.40	Rising	
		64.34	South Switch, Rising Siding	
		64.32	Switch, State Line Siding	
		64	**Milepost**	
	526199X	63.96	Van Duesenville Road	+0.5
	526198R	63.67	Division Street	
		63.63	Bridge	
		Bridge 63.16		
	526207M	63.32	Cullitins North	
	526208U	63.25	Cullitins South	
		63	**Milepost**	-0.1
	526209B	62.86	O'Connor's	
	526243H	62.60	Hulls North	
	526242B	62.51	Hulls South	
	526241U	62.34	Farm	
		62.00	**Milepost**	

State Line Track 350 Ft. **5 MPH**

Siding 2000 Ft. **5 MPH**

EMERGENCY RESPONSE

Stockbridge Police (413) 298-4179

Great Barrington Police Dept. (413) 528-0306

Berkshire County Sheriff (413) 445-4559

Timetable 3

HOUSATONIC RAILROAD

Berkshire Line – BL-62 to BL-57

South

Speed	DOT#	BL-Mileage	Location	Grade
25 MPH		**62**	**Milepost**	
	526211C	61.77	Pearl Street	
	526212J	61.45	Bridge, North Plain Road	
		Bridge 61.38		
	526213R	61.18	Gas House Lane	
	526214X	61.07	High Street	
		61	**Milepost**	
	526215E	60.96	Rosseter Street	
		60.76	North Switch, Great Barrington Sdg.	
		60.74	Great Barrington	+0.2
		60.72	Bridge, Saint James Place	
		60.64	South Switch, Great Barrington Sdg.	
	526217T	60.52	South Street	
	526218A	60.18	Maple Avenue	
		60	**Milepost**	+0.9
	526219G	59.99	Silver Street	
		59.50	(Grade Change)	
		59	**Milepost**	
		58.89	Bridge	
		58.60	Bridge	
		58.39	Bridge	
	526221H	58.13	Lynings	+0.1
		58	**Milepost**	
	932734A	57.85	Appalachian Trail	
	526223W	57.47	Lime Kiln Road	Measured Mile
		57.30	Switch, Lanes	
		57	**Milepost**	

Great Barrington Siding
400 Feet

EMERGENCY RESPONSE

Great Barrington Police Dept. (413) 528-0306

Sheffield Police (413) 229-8522

Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-57 to BL-51

South

Speed	DOT#	BL-Mileage	Location	Grade
25 MPH		**57**	**Milepost**	-0.2
		56.36	Bridge	
	526224D	56.35	Sheffield Pottery	
		56	**Milepost**	Undulating Grade +/- 0.3
	526225K	55.97	Egremont Road	
	526226S	55.55	Cook Road	
		55.28	Bridge	
		55.08	Bridge	
	526227Y	55.04	Miller Avenue	
		55	**Milepost**	
		54.90	Bridge	
		54.70	Switch, Sheffield Team Track	
	526228F	54.50	Berkshire School Road	
	526230G	54.08	Root Lane	
		54	**Milepost**	
	526231N	53.80	Private	
	526232V	53.51	Silver Street	
		53.32	Switch, Silver Street	
		53	**Milepost**	
		52.90	(Grade Change)	+0.5
	526233C	52.34	Rannapo Road	
		52	**Milepost**	-0.7
		51.73	Bridge, Housatonic River	
	526234J	51.56	Farm	
		51.50	(Grade Change)	
	526237E	51.40	Bridge, Route 7A	
		51	**Milepost**	

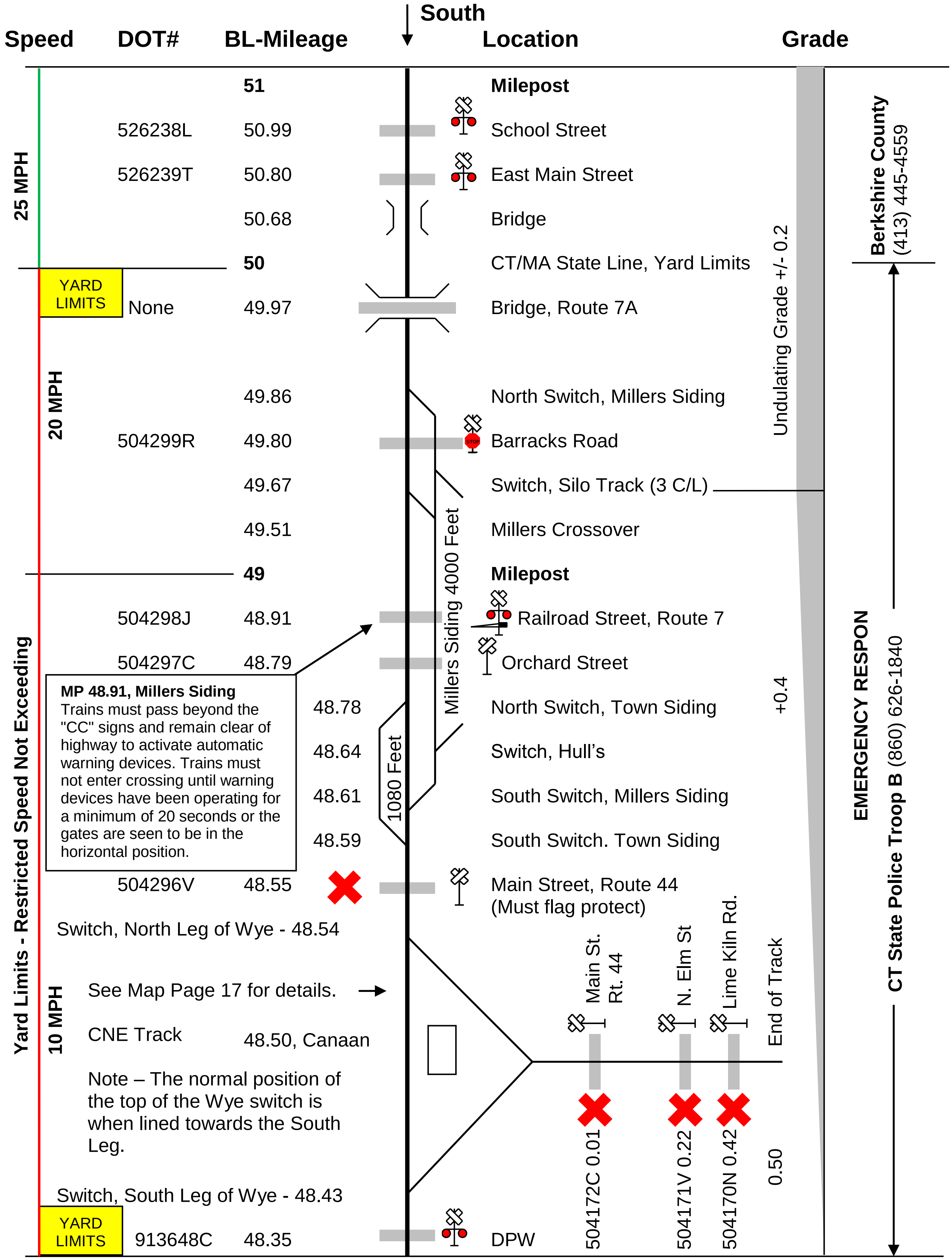
EMERGENCY RESPONSE

Sheffield Police Dept. (413) 229-8522

Berkshire County Sheriff (413) 445-4559

HOUSATONIC RAILROAD

Berkshire Line – BL-51 to BL-48.35



APPENDIX D

BR. 77.04 SURVEY INFORMATION

(BR. 77.16 = BR. 77.04)

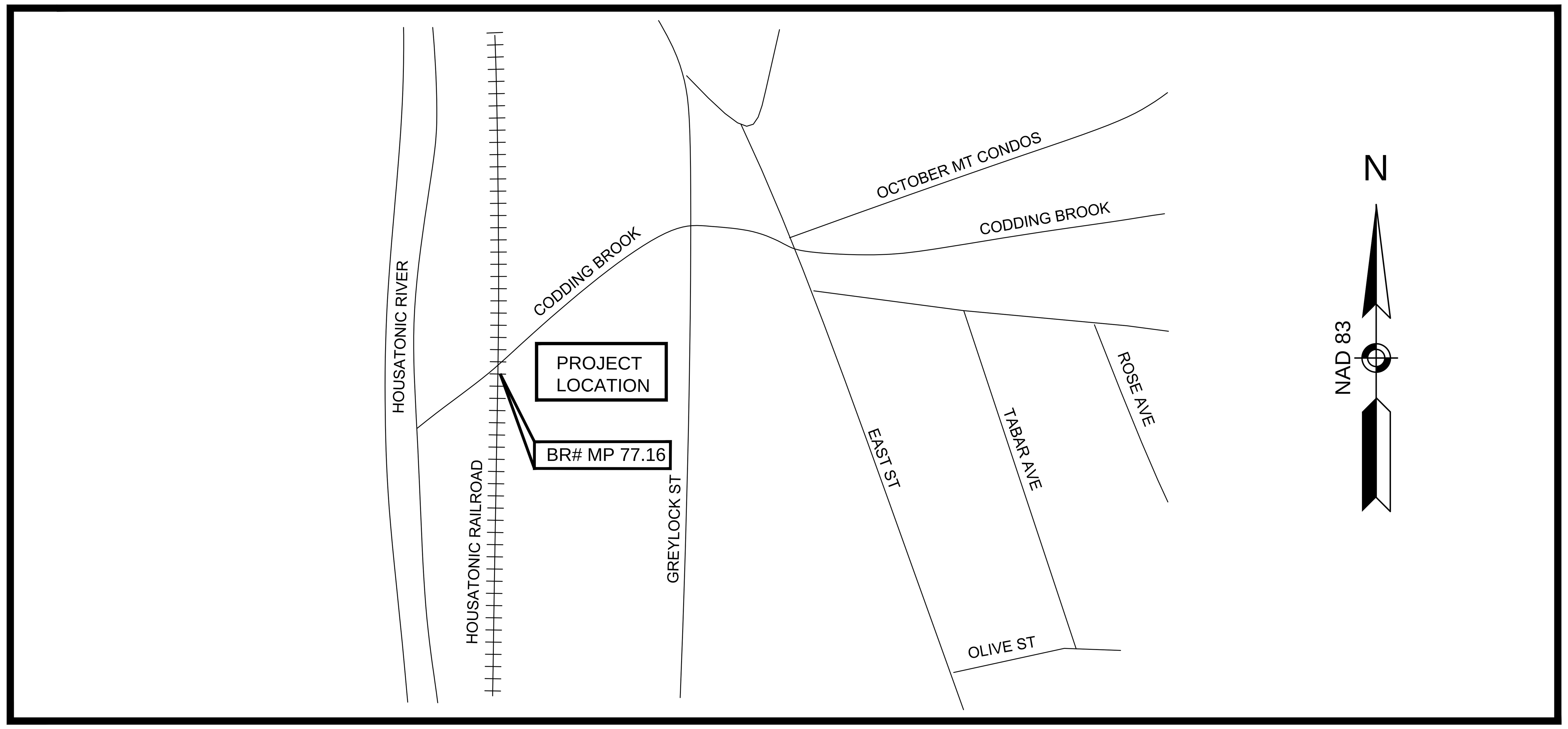
LEE
HOUSATONIC RR OVER CODDING BROOK

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	1	5
PROJECT FILE NO.	XXXXXX		

TITLE SHEET, LEGEND & ABBREVIATIONS

Plotted on 12-Oct-2018 3:51 PM

BRIDGE MP 77.16(LEE)_SV.DWG



0 20 50 100

SCALE: 1" = 20'

ABBREVIATIONS

AUX	AUXILARY	GMH	GAS MANHOLE	SHLD	SHOULDER
BD	BOUND	GRAN	GRANITE	SHLO	STATE HIGHWAY LAYOUT
BIT	BITUMINOUS	GRAV	GRAVEL	SK	SKEW
℞	BASELINE	GRD	GUARD	SL	STOP LINE
BLDG	BUILDING	GRL	GUARDRAIL	SMH	SEWER MANHOLE
BM	BENCHMARK	HDW	HEADWALL	SPK	SPIKE
BR	BRIDGE	HYD	HYDRANT	STA	STATION
BRK	BRICK	INV	INVERT	STN	STONE
BWL	BROKEN WHITE LINE	IP	IRON PIPE	SW	SIDEWALK
BYL	BROKEN YELLOW LINE	JB	JERSEY BARRIER	SWL	SOLID WHITE LINE
CAB	CABINET	L	LENGTH OF CURVE	SYL	SOLID YELLOW LINE
CB	CATCH BASIN	LB	LEACHING BASIN	T	TANGENT DISTANCE
CC	CEMENT CONCRETE	LC	LAND COURT	TAN	TANGENT
CCB	CAPE COD BERM	LCB	LAND COURT BOUND	TEMP	TEMPORARY
CEN	CENTER	LCD	LAND COURT DISK	TMH	TELEPHONE MANHOLE
CI	CURB INLET	LO	LAYOUT	TR	TOP OF RAIL
CIP	CAST IRON PIPE	LP	LIGHT POLE	TSC	TRAFFIC SIGNAL CONDUIT
℄	CENTER LINE	LPD	LIGHT POLE DOUBLE LIGHT	TYP	TYPICAL
CLF	CHAIN LINK FENCE	LSA	LANDSCAPED AREA	VAR	VARIABLE
CMH	CABLE MANHOLE	MAG	MAG NAIL	VCP	VITRIFIED CLAY PIPE
CMP	CORRUGATED METAL PIPE	MBE	MIDDLE BACK EDGE	VGC	VERTICAL GRANITE CURB
CO	COUNTY	MED	MEDIAN	VLT	VAULT
CO BD	COUNTY BOUND	MH	MANHOLE	WB	WESTBOUND
CON	CONIFEROUS	MP	MILE POST	WCR	WHEELCHAIR RAMP
CONC	CONCRETE	MTL	METAL	WD	WOOD
CPP	CORRUGATED PLASTIC PIPE	N/F	NOW OR FORMERLY	WIP	WROUGHT IRON PIPE
CSP	CORRUGATED STEEL PIPE	NB	NORTHBOUND		
CULV	CULVERT	OH	OVERHANG		
CW	CROSSWALK	OHW	OVERHEAD WIRE		
DBWL	DOUBLE WHITE LINE	PC	POINT OF CURVATURE		
DBYL	DOUBLE YELLOW LINE	PCC	POINT OF COMPOUND CURVATURE		
DEC	DECIDUOUS	PED	PEDESTRIAN		
DH	DRILL HOLE	PI	POINT OF INTERSECTION		
DI	DROP INLET	PK	PK NAIL		
DIA	DIAMETER	ℙ	PROPERTY LINE		
DIP	DUCTILE IRON PIPE	PP	PRICK PUNCH		
DMH	DRAIN MANHOLE	PRC	POINT OF REVERSE CURVATURE		
DSK	DISK	PT	POINT OF TANGENCY		
DWL	DOTTED WHITE LINE	PVC	POLYVINYL CHLORIDE PIPE		
DYL	DOTTED YELLOW LINE	PVMT	PAVEMENT		
EB	EASTBOUND	PWW	PAVED WATERWAY		
EL	ELEVATION	PZ	PIEZOMETER		
EMH	ELECTRIC MANHOLE	R	RADIUS OF CURVATURE		
EP	EDGE OF PAVEMENT	RB	REBAR		
EPLP	ESCUTCHEON PIN IN LEAD PLUG	RC	REINFORCED CONCRETE		
ETW	EDGE OF TRAVELED WAY	RCP	REINFORCED CONCRETE PIPE		
EX	EXISTING	RET	RETAINING		
FF	FINISH FLOOR	ROW	RIGHT OF WAY		
FGS	FLAGSTONE	RR	RAILROAD		
FL	FLOWLINE	RRS	RAILROAD SPIKE		
FLDSTN	FIELDSTONE	S BD	SOUTHBOUND		
GAR	GARAGE	SB	STONE BOUND		
GD	GROUND	SD	SUBDRAIN		
GIP	GALVANIZED IRON PIPE	SGE	SLOPED GRANITE EDGING		

LEGEND

BF#	BANK FLAG	MAG	MAG NAIL	TS	TRAFFIC SIGNAL
BHL #	BORE HOLE	MB	MAIL BOX	TS	TRAFFIC SIGNAL MAST ARM/SPAN WIRE POLE
	BUSH	MHB	MASSACHUSETTS HIGHWAY BOUND		SIGN
BM #	BENCHMARK	MW	MONITORING WELL		SIGN - DOUBLE POST
	BOUND (CONC, STONE, LAND COURT, ETC.)	OIL	OIL FILL	UFB#	UTILITY POLE W/ FIRE PULL BOX
	CABLE MANHOLE		OTHER MANHOLE	ULT#	UTILITY POLE W/ LIGHT
CB	CATCH BASIN - SQUARE	PB	PULL BOX	UPDL#	UTILITY POLE W/ DOUBLE LIGHT
CB	CATCH BASIN - D-FRAME	PED	PEDESTRIAN SIGNAL	UPL#	UTILITY POLE
CB	CATCH BASIN - ROUND		PHOTO CONTROL - H & V	VP	VENT PIPE
DSK	DISK (CA/T, USC&GS, LAND COURT, ETC.)		PHOTO CONTROL - V ONLY		WATER MANHOLE
DH	DRILL HOLE	PK	PK NAIL	WG	WATER GATE
	DRAIN MANHOLE	PM	PARKING METER	WM	WATER METER
EHH	ELECTRIC HANDHOLE	POST	CIRCULAR POST	WSO	WATER SHUTOFF
	ELECTRIC MANHOLE	POST	SQUARE POST	WELL	WELL (POTABLE)
EM	ELECTRIC METER	RB	REBAR/IRON PIN	WF#	WETLAND FLAG
EPLP	ESCUTCHEON PIN IN LEAD PLUG	RRS	RAILROAD SPIKE	X-CUT	X-CUT
FB	FLASHING BEACON	RRSG	RAILROAD SIGNAL		
FES	FLARED END SECTION	RRSW	RAILROAD SWITCH		
FP	FLAG POLE	SN	STAKE AND NAIL		
GF	GAS FILL	SP	STAND PIPE		
GG	GAS GATE		SEWER MANHOLE		
GM	GAS METER		STEAM MANHOLE		
GP	GAS PUMP		STUMP		
	GAS MANHOLE	TB	TOWN LINE BOUND (CORNER)		
GPL	GUY POLE	TCB	TRAFFIC SIGNAL CONTROL CABINET		
	HANDICAP SYMBOL		TELEPHONE MANHOLE		
	GUY WIRE ANCHOR	TFMR	TRANSFORMER		
HTP	HIGH TENSION POWER POLE	TLRS	TOWN LINE ROAD STONE		
	FIRE HYDRANT	TPIT #	TEST PIT		
IP	IRON PIPE	TPL	TROLLEY POLE		
	LIGHT POLE		TRAVERSE POINT		
	LIGHT POLE DOUBLE LIGHT	22"M	TREE		

NOTES

1. THIS PLAN REPRESENTS AN ON THE GROUND INSTRUMENT SURVEY PERFORMED ON OCTOBER 3, 2018 BY C&C CONSULTING ENGINEERS, LLC.
2. CONTROL POINTS DETERMINED BY GLOBAL POSITIONING SYSTEM METHOD BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD–1983), MASSACHUSETTS STATE COORDINATE SYSTEM (MAINLAND ZONE) AND VERTICAL DATUM BASED UPON THE NORTH AMERICAN VERTICAL SYSTEM OF 1988 (NAVD–1988).

PRELIMINARY - 10.11.18

massDOT
Massachusetts Department of Transportation
Rail & Transit Division

PREPARED BY:

C&C
Consulting Engineers, LLC
1380 Soldiers Field Road, Boston, MA 02135
617-254-6930 (voice) 617-254-7631 (fax)

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
PLAN OF TOPOGRAPHIC SURVEY OF
HOUSATONIC RR OVER CODDING BROOK
(BRIDGE NO. 77.16)
IN THE TOWN OF
LEE
AS ORDERED BY
THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION,
RAIL & TRANSIT DIVISION

REVISIONS

REV.	COMMENTS	DATE

SCALE: 20 FEET TO THE INCH

FILE NAME: BRIDGE MP 77.16(LEE)_SV	
FIELD BOOK. NO: XXXX	
DRAWN BY: MG	CHECKED BY: GCW
FIELD CHIEF: HF	PARS. NO: XXXXXXX

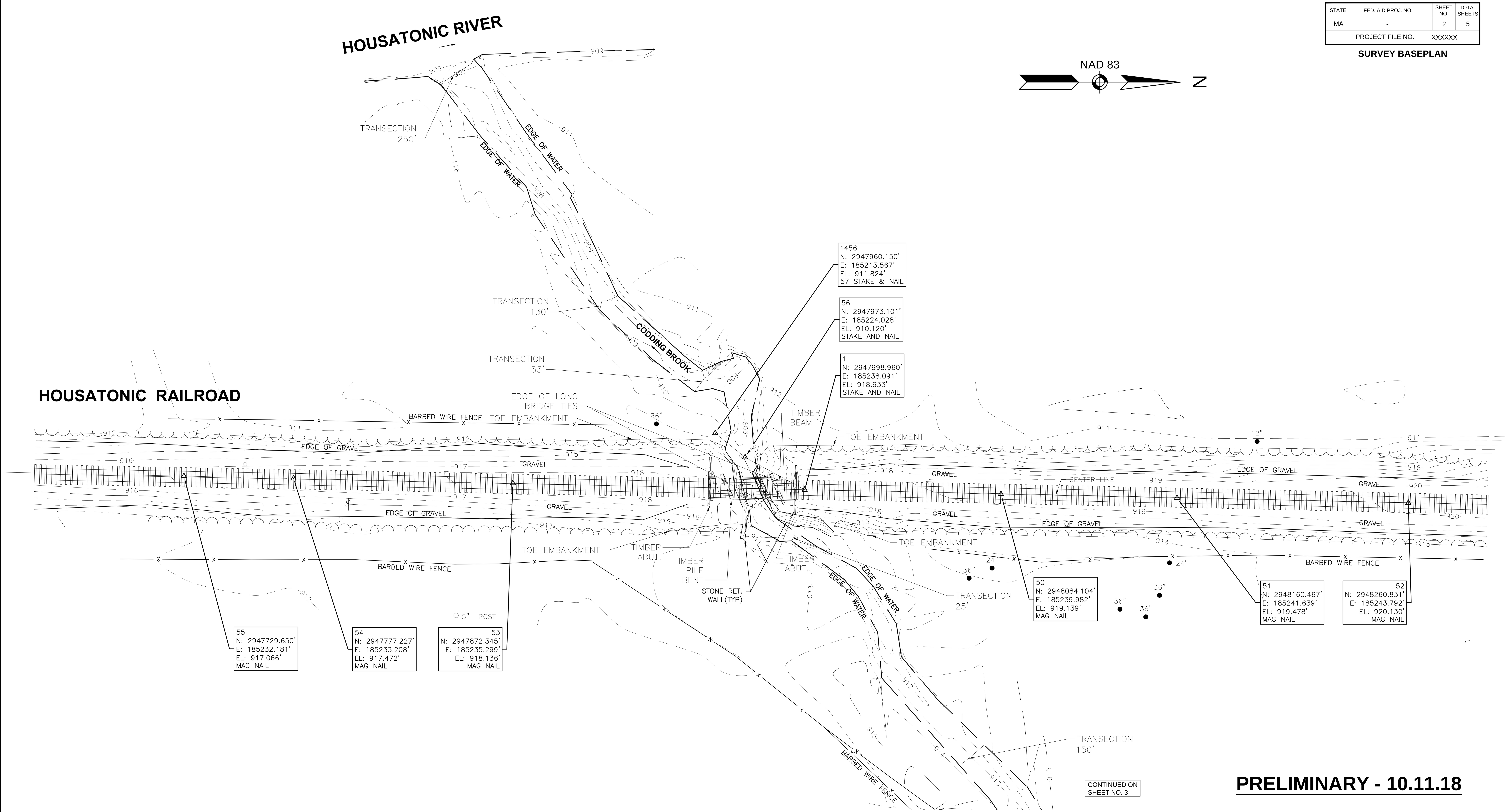
DATE: OCTOBER 11, 2018

SHEET 1 OF 5

LEE
HOUSATONIC RR OVER CODDING BROOK

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	2	5
PROJECT FILE NO.	XXXXXX		

SURVEY BASEPLAN



CONTINUED ON SHEET NO. 3

PRELIMINARY - 10.11.18

0 20 50 100
SCALE: 1" = 20'

massDOT Massachusetts Department of Transportation Rail & Transit Division

PREPARED BY:
C&C Consulting Engineers, LLC
1380 Soldiers Field Road, Boston, MA 02135
617-254-6930 (voice) 617-254-7631 (fax)

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
PLAN OF TOPOGRAPHIC SURVEY OF
HOUSATONIC RR OVER CODDING BROOK
(BRIDGE NO. 77.16)
IN THE TOWN OF
LEE
AS ORDERED BY
THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION, RAIL & TRANSIT DIVISION

REVISIONS

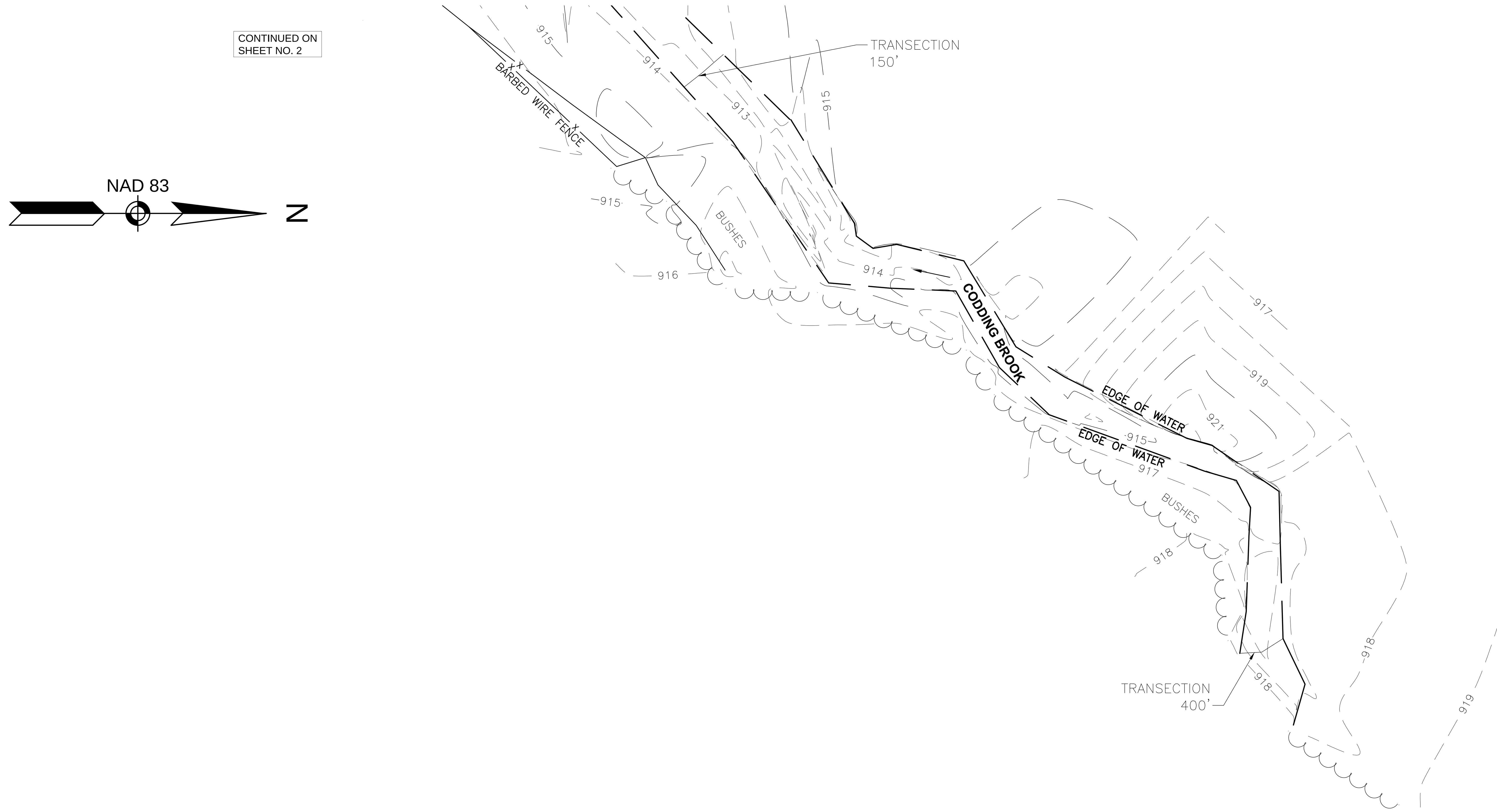
REV.	COMMENTS	DATE

SCALE: 20 FEET TO THE INCH

FILE NAME: BRIDGE MP 77.16(LEE)_SV
FIELD BOOK. NO: XXXX
DRAWN BY: MG CHECKED BY: GCW
FIELD CHIEF: HF PARS. NO: XXXXXXX

DATE: OCTOBER 11, 2018 SHEET 2 OF 5

CONTINUED ON SHEET NO. 2



LEE
HOUSATONIC RR OVER CODDING BROOK

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	3	5
PROJECT FILE NO.	XXXXXX		

SURVEY BASEPLAN

PRELIMINARY - 10.11.18

0 20 50 100
SCALE: 1" = 20'

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Massachusetts Department of Transportation
Rail & Transit Division

PREPARED BY:
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HOUSATONIC RR OVER CODDING BROOK
(BRIDGE NO. 77.16)
IN THE TOWN OF
LEE
AS ORDERED BY
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REVISIONS

REV.	COMMENTS	DATE

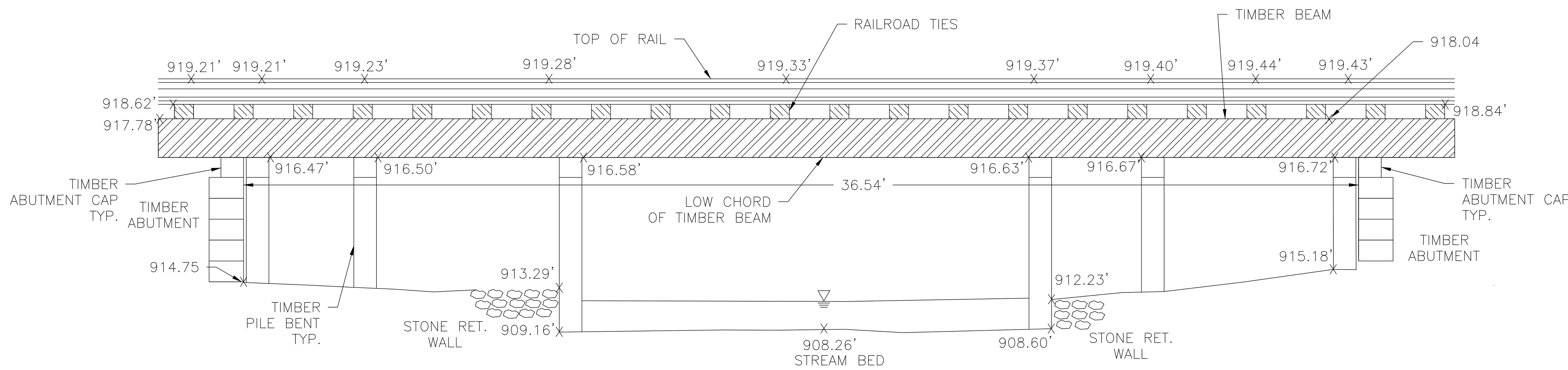
SCALE: 20 FEET TO THE INCH
FILE NAME: BRIDGE MP 77.16(LEE)_SV
FIELD BOOK. NO: XXXX
DRAWN BY: MG CHECKED BY: GCW
FIELD CHIEF: HF PARS. NO: XXXXXXX

DATE: OCTOBER 11, 2018
SHEET 3 OF 5

BRIDGE MP 77.16(LEE)_SV.DWG Plotted on 12-Oct-2018 3:51 PM

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	4	5
PROJECT FILE NO.	XXXXXX		

SURVEY BASEPLAN



ABUTMENT DETAIL – WEST SIDE LOOKING WEST
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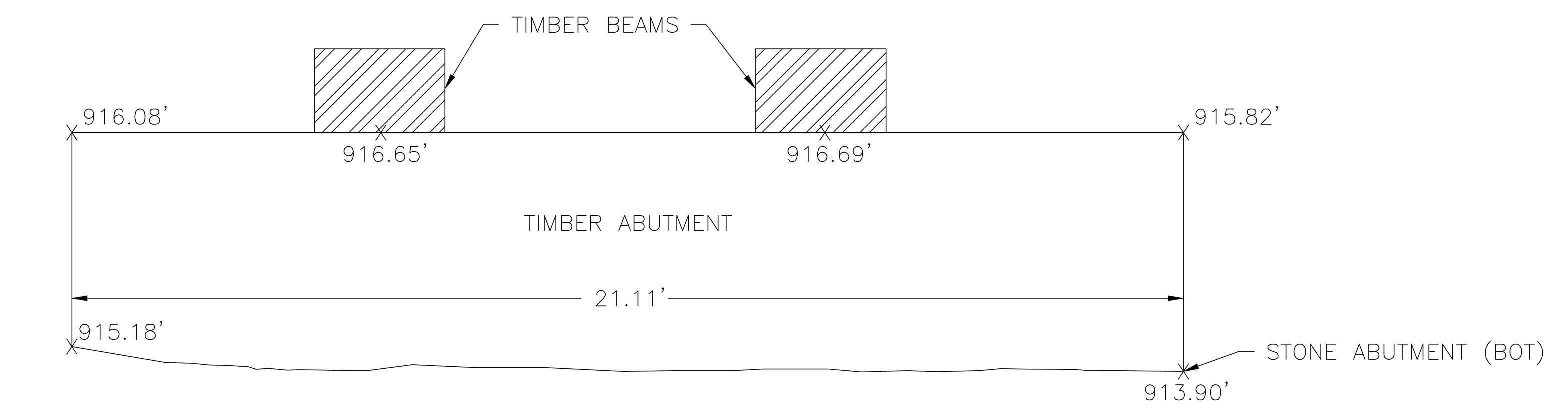

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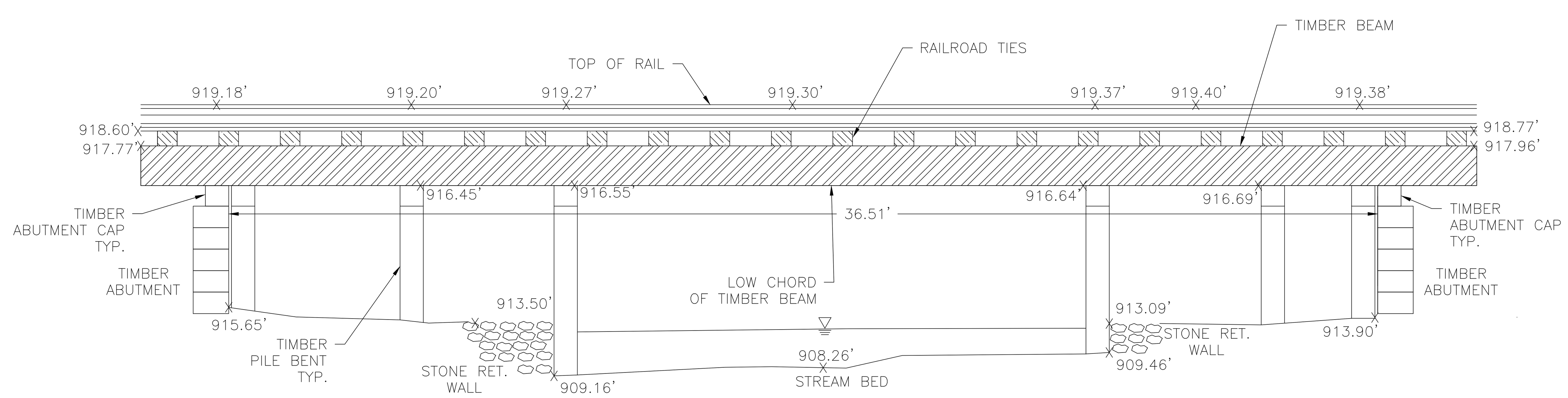

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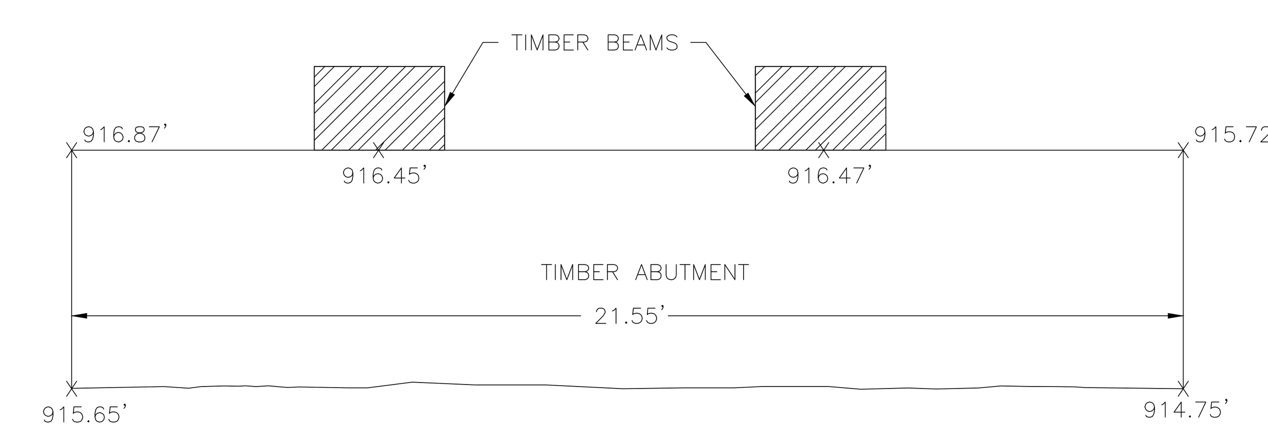

ABUTMENT DETAIL – SOUTH SIDE LOOKING SOUTH
SCALE: NOT TO SCALE

PRELIMINARY - 10.11.18

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(BRIDGE NO. 77.16)
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REVISIONS

REV.	COMMENTS	DATE

SCALE: 20 FEET TO THE INCH

FILE NAME: BRIDGE MP 77.16(LEE)_SV	
FIELD BOOK. NO: XXXX	
DRAWN BY: MG	CHECKED BY: GCW
FIELD CHIEF: HF	PARS. NO: XXXXXXX

DATE: OCTOBER 11, 2018 SHEET 4 OF 5

BRIDGE MP 77.16(LEE)_SV.DWG Plotted on 12-Oct-2018 3:51 PM

LEE
HOUSATONIC RR OVER CODDING BROOK

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	5	5
PROJECT FILE NO.	XXXXXX		

SURVEY BASEPLAN

SECTION: 25' (NORTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1429	2947994.252	185258.357	908.872	BROOK
1430	2947993.377	185260.261	909.687	EW
2304	2947994.434	185256.005	909.480	Transection 25' US

SECTION: 53' (SOUTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1407	2947951.193	185195.502	909.046	EW
1408	2947954.627	185186.271	906.915	EW
1409	2947955.391	185189.829	907.718	BROOK

SECTION: 130' (SOUTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1416	2947913.069	185156.154	907.232	BROOK
1417	2947917.919	185154.014	908.266	EW
1418	2947910.054	185160.160	907.654	EW
2164	2947910.979	185156.161	907.547	BROOK

SECTION: 150' (NORTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
2300	2948066.207	185357.717	913.800	Transection 150' US
2301	2948071.074	185353.889	913.000	Transection 150' US
2302	2948074.331	185351.023	913.000	Transection 150' US
2303	2948076.886	185348.835	913.770	Transection 150' US

SECTION: 250' (SOUTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
2206	2947855.381	185051.232	909.467	EW RIVER
2208	2947854.454	185053.131	907.127	RIVER
2223	2947841.320	185062.470	909.721	B EW RIVER
2225	2947842.268	185061.108	907.922	BROOK

SECTION: 400' (NORTH)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
2050	2948229.471	185508.150	916.311	EW
2051	2948223.686	185511.842	915.886	BROOK
2052	2948217.686	185512.166	917.651	EW

SECTION: TOE EMBANKMENT (SE)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1197	2947926.593	185257.864	912.884	VGWL/BS
1280	2947972.153	185253.224	913.143	WLST
1555	2947968.660	185252.808	914.323	PELV
1558	2947960.283	185253.616	915.297	PELV

SECTION: TOE EMBANKMENT (NE)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1220	2948044.766	185257.259	913.385	VGWL/BS
1221	2948026.356	185257.963	912.322	VGWL/BS
1222	2948011.783	185253.520	913.170	E VGWL/BS

SECTION: TOE EMBANKMENT (NW)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1207	2947983.517	185218.758	913.529	B VGWL/BS
1208	2948022.602	185219.119	912.164	VGWL/BS
1209	2948047.829	185218.352	912.549	VGWL/BS
1298	2947979.880	185223.218	910.905	E WLST

SECTION: TOE EMBANKMENT (SW)

Point Table				
Point #	Northing	Easting	Elevation	Raw Description
1199	2947957.405	185216.477	912.148	B VGWL/BS
1200	2947937.478	185215.855	912.609	VGWL/BS
1201	2947906.968	185216.791	911.992	VGWL/BS
1271	2947964.177	185219.260	910.124	B WLST

PRELIMINARY - 10.11.18

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Massachusetts Department of Transportation
Rail & Transit Division

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MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
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(BRIDGE NO. 77.16)
IN THE TOWN OF
LEE
AS ORDERED BY
THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION,
RAIL & TRANSIT DIVISION

REVISIONS

REV.	COMMENTS	DATE

SCALE: 20 FEET TO THE INCH

FILE NAME: BRIDGE MP 77.16(LEE)_SV
FIELD BOOK. NO: XXXX
DRAWN BY: MG CHECKED BY: GCW
FIELD CHIEF: HF PARS. NO: XXXXXXX
DATE: OCTOBER 11, 2018 SHEET 5 OF 5

BRIDGE MP 77.16(LEE)_SV.DWG Plotted on 12-Oct-2018 3:51 PM

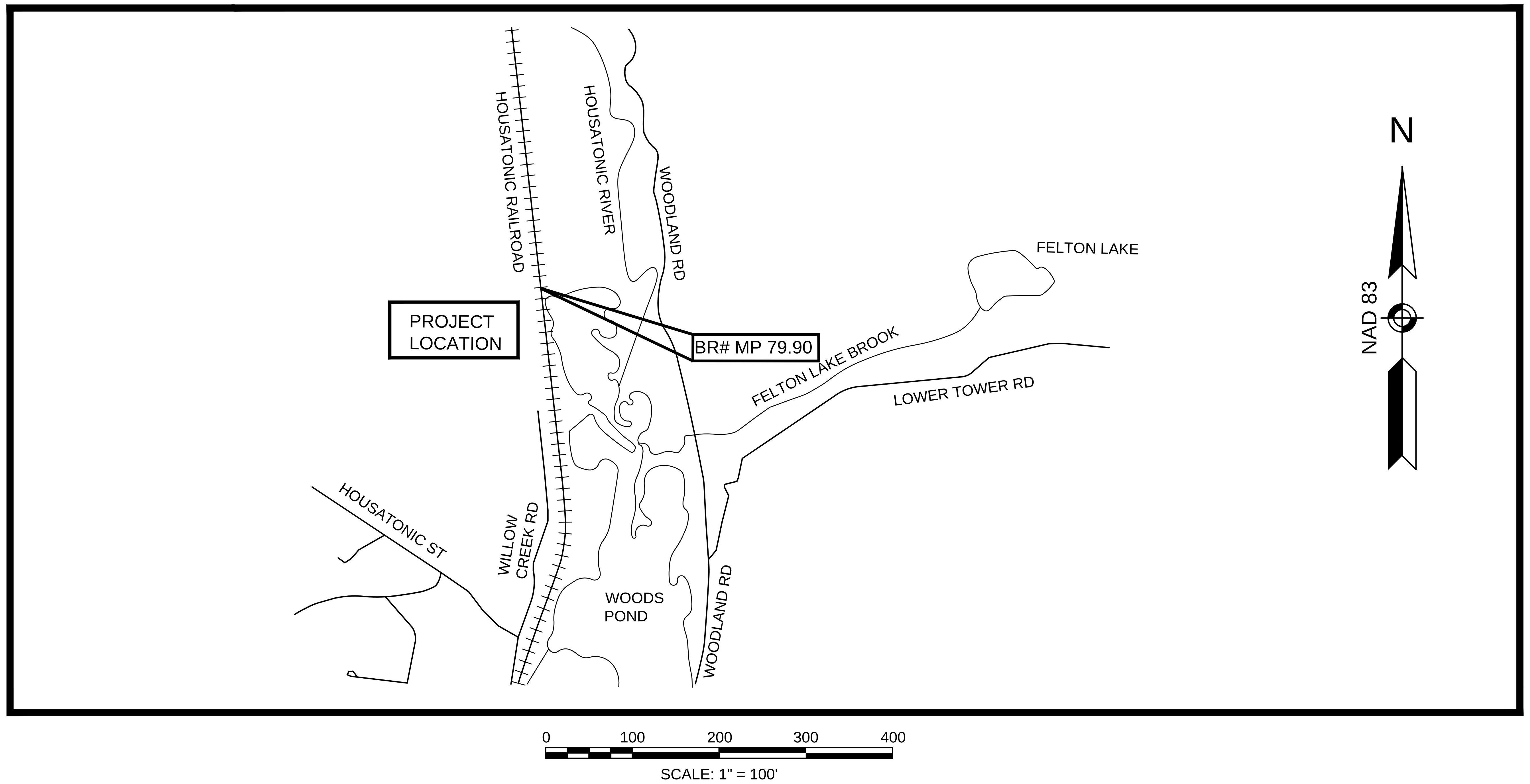
BR. 79.81 SURVEY INFORMATION

(BR. 79.90 = BR. 79.81)

LENOX
HOUSATONIC RR OVER POND OVERFLOW

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	1	X
PROJECT FILE NO.	XXXXXX		

TITLE SHEET, LEGEND & ABBREVIATIONS



ABBREVIATIONS

AUX	AUXILARY
BD	BOUND
BIT	BITUMINOUS
℄	BASELINE
BLDG	BUILDING
BM	BENCHMARK
BR	BRIDGE
BRK	BRICK
BWL	BROKEN WHITE LINE
BYL	BROKEN YELLOW LINE
CAB	CABINET
CB	CATCH BASIN
CC	CEMENT CONCRETE
CCB	CAPE COD BERM
CEN	CENTER
CI	CURB INLET
CIP	CAST IRON PIPE
℄	CENTER LINE
CLF	CHAIN LINK FENCE
CMH	CABLE MANHOLE
CMP	CORRUGATED METAL PIPE
CO	COUNTY
CO BD	COUNTY BOUND
CON	CONIFEROUS
CONC	CONCRETE
CPP	CORRUGATED PLASTIC PIPE
CSP	CORRUGATED STEEL PIPE
CULV	CULVERT
CW	CROSSWALK
DBWL	DOUBLE WHITE LINE
DBYL	DOUBLE YELLOW LINE
DEC	DECIDUOUS
DH	DRILL HOLE
DI	DROP INLET
DIA	DIAMETER
DIP	DUCTILE IRON PIPE
DMH	DRAIN MANHOLE
DSK	DISK
DWL	DOTTED WHITE LINE
DYL	DOTTED YELLOW LINE
EB	EASTBOUND
EL	ELEVATION
EMH	ELECTRIC MANHOLE
EP	EDGE OF PAVEMENT
EPLP	ESCUTCHEON PIN IN LEAD PLUG
ETW	EDGE OF TRAVELED WAY
EX	EXISTING
FF	FINISH FLOOR
FGS	FLAGSTONE
FL	FLOWLINE
FLDSTN	FIELDSTONE
GAR	GARAGE
GD	GROUND
GIP	GALVANIZED IRON PIPE

GMH	GAS MANHOLE
GRAN	GRANITE
GRAV	GRAVEL
GRD	GUARD
GRL	GUARDRAIL
HDW	HEADWALL
HYD	HYDRANT
INV	INVERT
IP	IRON PIPE
JB	JERSEY BARRIER
L	LENGTH OF CURVE
LB	LEACHING BASIN
LC	LAND COURT
LCB	LAND COURT BOUND
LCD	LAND COURT DISK
LO	LAYOUT
LP	LIGHT POLE
LPD	LIGHT POLE DOUBLE LIGHT
LSA	LANDSCAPED AREA
MAG	MAG NAIL
MBE	MIDDLE BACK EDGE
MED	MEDIAN
MH	MANHOLE
MP	MILE POST
MTL	METAL
N/F	NOW OR FORMERLY
NB	NORTHBOUND
OH	OVERHANG
OHW	OVERHEAD WIRE
PC	POINT OF CURVATURE
PCC	POINT OF COMPOUND CURVATURE
PED	PEDESTRIAN
PI	POINT OF INTERSECTION
PK	PK NAIL
ℙ	PROPERTY LINE
PP	PRICK PUNCH
PRC	POINT OF REVERSE CURVATURE
PT	POINT OF TANGENCY
PVC	POLYVINYL CHLORIDE PIPE
PVMT	PAVEMENT
PWW	PAVED WATERWAY
PZ	PIEZOMETER
R	RADIUS OF CURVATURE
RB	REBAR
RC	REINFORCED CONCRETE
RCP	REINFORCED CONCRETE PIPE
RET	RETAINING
ROW	RIGHT OF WAY
RR	RAILROAD
RRS	RAILROAD SPIKE
S BD	SOUTHBOUND
SB	STONE BOUND
SD	SUBDRAIN
SGE	SLOPED GRANITE EDGING

SHLD	SHOULDER
SHLO	STATE HIGHWAY LAYOUT
SK	SKEW
SL	STOP LINE
SMH	SEWER MANHOLE
SPK	SPIKE
STA	STATION
STN	STONE
SW	SIDEWALK
SWL	SOLID WHITE LINE
SYL	SOLID YELLOW LINE
T	TANGENT DISTANCE
TAN	TANGENT
TEMP	TEMPORARY
TMH	TELEPHONE MANHOLE
TR	TOP OF RAIL
TSC	TRAFFIC SIGNAL CONDUIT
TYP	TYPICAL
VAR	VARIABLE
VCP	VITRIFIED CLAY PIPE
VGC	VERTICAL GRANITE CURB
VLT	VAULT
WB	WESTBOUND
WCR	WHEELCHAIR RAMP
WD	WOOD
WIP	WROUGHT IRON PIPE

LEGEND

BF#	BANK FLAG
BHL #	BORE HOLE
	BUSH
BM #	BENCHMARK
	BOUND (CONC, STONE, LAND COURT, ETC.)
	CABLE MANHOLE
CB	CATCH BASIN - SQUARE
CB	CATCH BASIN - D-FRAME
CB	CATCH BASIN - ROUND
DSK	DISK (CA/T, USC&GS, LAND COURT, ETC.)
DH	DRILL HOLE
	DRAIN MANHOLE
EHH	ELECTRIC HANDHOLE
	ELECTRIC MANHOLE
EM	ELECTRIC METER
EPLP	ESCUTCHEON PIN IN LEAD PLUG
FB	FLASHING BEACON
FES	FLARED END SECTION
FP	FLAG POLE
GF	GAS FILL
GG	GAS GATE
GM	GAS METER
GP	GAS PUMP
	GAS MANHOLE
GPL	GUY POLE
	HANDICAP SYMBOL
	GUY WIRE ANCHOR
HTP	HIGH TENSION POWER POLE
	FIRE HYDRANT
IP	IRON PIPE
	LIGHT POLE
	LIGHT POLE DOUBLE LIGHT

MAG	MAG NAIL
MB	MAIL BOX
MHB	MASSACHUSETTS HIGHWAY BOUND
MW	MONITORING WELL
OIL	OIL FILL
	OTHER MANHOLE
PB	PULL BOX
PED	PEDESTRIAN SIGNAL
	PHOTO CONTROL - H & V
	PHOTO CONTROL - V ONLY
PK	PK NAIL
PM	PARKING METER
POST	CIRCULAR POST
POST	SQUARE POST
RB	REBAR/IRON PIN
RRS	RAILROAD SPIKE
RRSG	RAILROAD SIGNAL
RRSW	RAILROAD SWITCH
SN	STAKE AND NAIL
SP	STAND PIPE
	SEWER MANHOLE
	STEAM MANHOLE
	STUMP
TB	TOWN LINE BOUND (CORNER)
TCB	TRAFFIC SIGNAL CONTROL CABINET
	TELEPHONE MANHOLE
TFMR	TRANSFORMER
TLRS	TOWN LINE ROAD STONE
TPIT #	TEST PIT
TPL	TROLLEY POLE
	TRAVERSE POINT
22"M	TREE

TS	TRAFFIC SIGNAL
TS	TRAFFIC SIGNAL MAST ARM/SPAN WIRE POLE
	SIGN
	SIGN - DOUBLE POST
UFB#	UTILITY POLE W/ FIRE PULL BOX
ULT#	UTILITY POLE W/ LIGHT
UPDL#	UTILITY POLE W/ DOUBLE LIGHT
UPL#	UTILITY POLE
VP	VENT PIPE
	WATER MANHOLE
WG	WATER GATE
WM	WATER METER
WSO	WATER SHUTOFF
WELL	WELL (POTABLE)
WF#	WETLAND FLAG
X-CUT	X-CUT

NOTES

1. THIS PLAN REPRESENTS AN ON THE GROUND INSTRUMENT SURVEY PERFORMED ON OCTOBER 3, 2018 BY C&C CONSULTING ENGINEERS, LLC.
2. CONTROL POINTS DETERMINED BY GLOBAL POSITIONING SYSTEM METHOD BASED UPON THE NORTH AMERICAN DATUM OF 1983 (NAD-1983), MASSACHUSETTS STATE COORDINATE SYSTEM (MAINLAND ZONE) AND VERTICAL DATUM BASED UPON THE NORTH AMERICAN VERTICAL SYSTEM OF 1988 (NAVD-1988).

PRELIMINARY 11.21.18

massDOT
Massachusetts Department of Transportation
Rail & Transit Division

PREPARED BY:

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MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
PLAN OF TOPOGRAPHIC SURVEY OF
HOUSATONIC RR OVER POND OVERFLOW
(BRIDGE NO. 79.90)
IN THE TOWN OF
LENOX
AS ORDERED BY
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RAIL & TRANSIT DIVISION

REVISIONS

REV.	COMMENTS	DATE

SCALE: 20 FEET TO THE INCH

FILE NAME: BRIDGE MP 79.90(LENOX)_SV	
FIELD BOOK. NO: 169	
DRAWN BY: MG	CHECKED BY: GCW
FIELD CHIEF: HF	PARS. NO: XXXXXXX

DATE: NOVEMBER 21, 2018

SHEET 1 OF X

BRIDGE MP 79.90(LENOX)_SV_11.21.18.DWG Plotted on 21-Nov-2018 11:22 AM

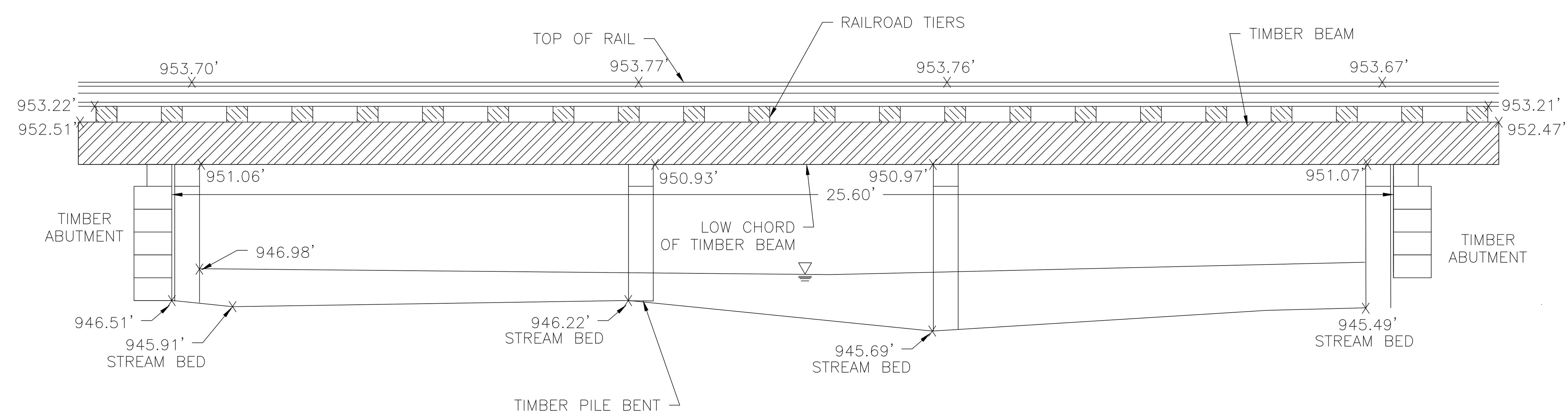
LENOX
HOUSATONIC RR OVER POND OVERFLOW

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	2	X
PROJECT FILE NO.	XXXXXX		

SURVEY BASEPLAN

Plotted on 21-Nov-2018 11:22 AM

BRIDGE MP 79.90(LENOX)_SV_11.21.18.DWG



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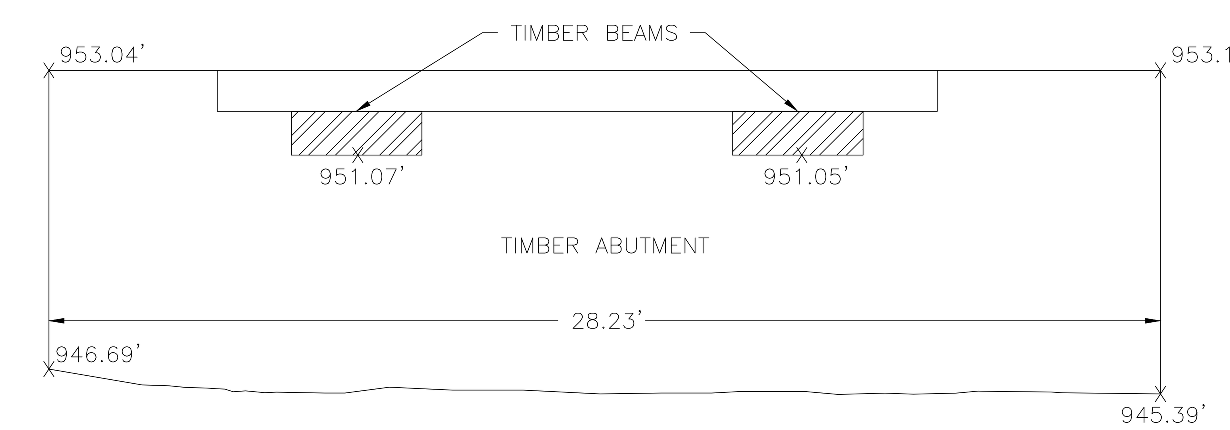
SCALE: NOT TO SCALE



ABUTMENT DETAIL – NORTH SIDE LOOKING NORTH
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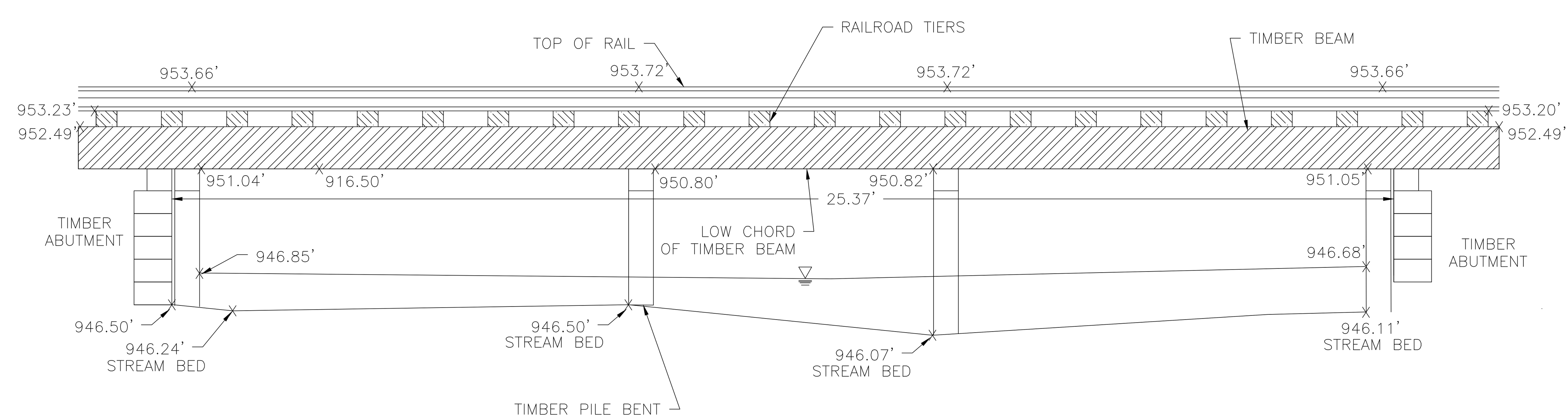

ABUTMENT DETAIL – EAST SIDE LOOKING WEST
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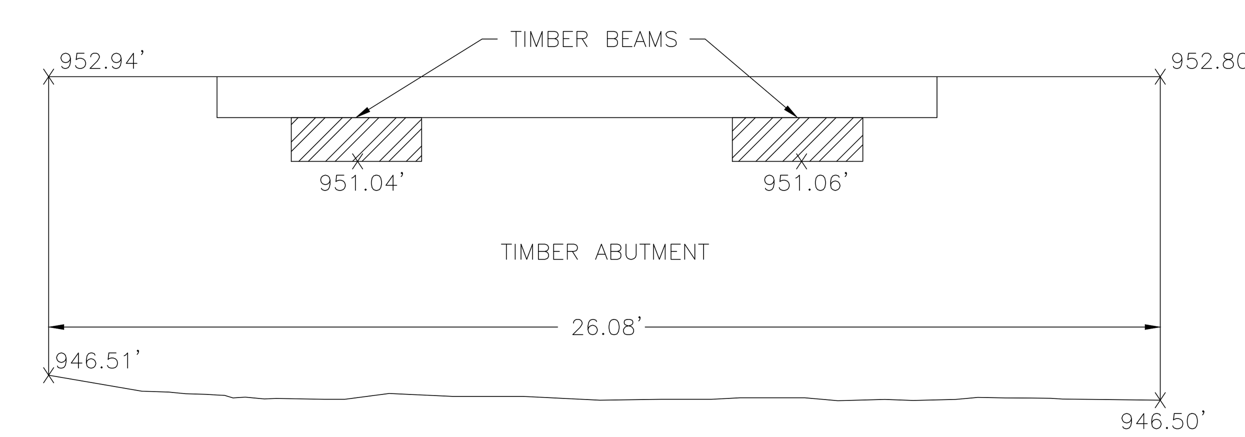

ABUTMENT DETAIL – SOUTH SIDE LOOKING SOUTH
SCALE: NOT TO SCALE

0 20 50 100
SCALE: 1" = 20'

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FIELD BOOK. NO: XXXX	
DRAWN BY: MG	CHECKED BY: GCW
FIELD CHIEF: HF	PARS. NO: XXXXXXX

DATE: OCTOBER XX, 2018 SHEET 1 OF X

APPENDIX E

Contractor COVID-19 Guidelines

Compliance Checklist:

Contract Number: ____________________ City/Town: ______________________

Contract Description: ____

Contractor Name: ____

YES	NO		
☐	☐	1.	Has the COVID-19 Guidelines and Procedures for all Construction Sites and Workers at all Public Work bulletin been posted in a location for workers to observe?
☐	☐	2.	Have all required PPE been made available to all on site personnel? Have all personnel been instructed on the best practices for the use of PPE prior to the start of the work shift?
☐	☐	3.	Have handwashing instructions been posted on the project site?
☐	☐	4.	For site specific project locations have wash stations been installed? (NOTE: For various location/district wide projects wash stations are not required. For those projects the contractor must provide disinfecting wipes and liquid hand sanitizer)
☐	☐	5.	Has a procedure been established for workers to certify their health to their supervisor prior to the start of each shift, and identified the responsible person on site to manage this provision?
☐	☐	6.	Has signage been posted to prohibit unauthorized visitors to enter the MassDOT and contractor field offices?
☐	☐	7.	Have jobsite cleaning and decontamination procedures been established? Have these been shared with contractor/subcontractor employees?
☐	☐	8.	Have jobsite cleaning and decontamination procedures been established and have they been posted on trailers, gates, equipment, vehicles, etc. at each entry point to the site, and throughout the project site?

massDOT

Massachusetts Department of Transportation

Contractor COVID-19 Guidelines

Compliance Checklist:

YES	NO		
☐	☐	9.	Has a “No Congregation” policy been put into effect that states that individuals must implement social distancing by maintaining a minimum distance of 6-feet from other individuals?
☐	☐	10.	Are all meetings being held via electronic means, and any required on-site meetings being done following social distancing practices including limiting attendance to 10 persons?
☐	☐	11.	Are individual crew meetings/tailgate talks being held outdoors and following social distancing requirements?
☐	☐	12.	Are all restroom and porta-potty stations being sanitized consistent with guidance, and are these locations provided with soap, hand sanitizers and paper towels?
☐	☐	13.	Have all field office common areas been cleaned in the last 24 hours; and soap, hand sanitizer, and paper towels provided?
☐	☐	14.	Have workers been instructed to bring food from home and practice appropriate hygiene while eating on lunch and at breaks including social distancing?
☐	☐	15.	Have employees been instructed about appropriate personal hygiene and about staying home when either they or a family member is feeling sick?
☐	☐	16.	Are all employees driving to the work site/ parking area in a single occupant vehicle?
☐	☐	17.	Are all employees utilizing the proper PPE for conditions where required social distancing is not achievable?

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Contractor COVID-19 Guidelines Compliance Checklist:

I hereby certify that the responses indicated on this document are accurate and that all the necessary actions have taken place on this day to comply with the COVID-19 Guidelines as issued by MassDOT

Name: ____

Signature:

Name: __________________________________ **Date:** ______________

Printed:

Position: ____

Printed: